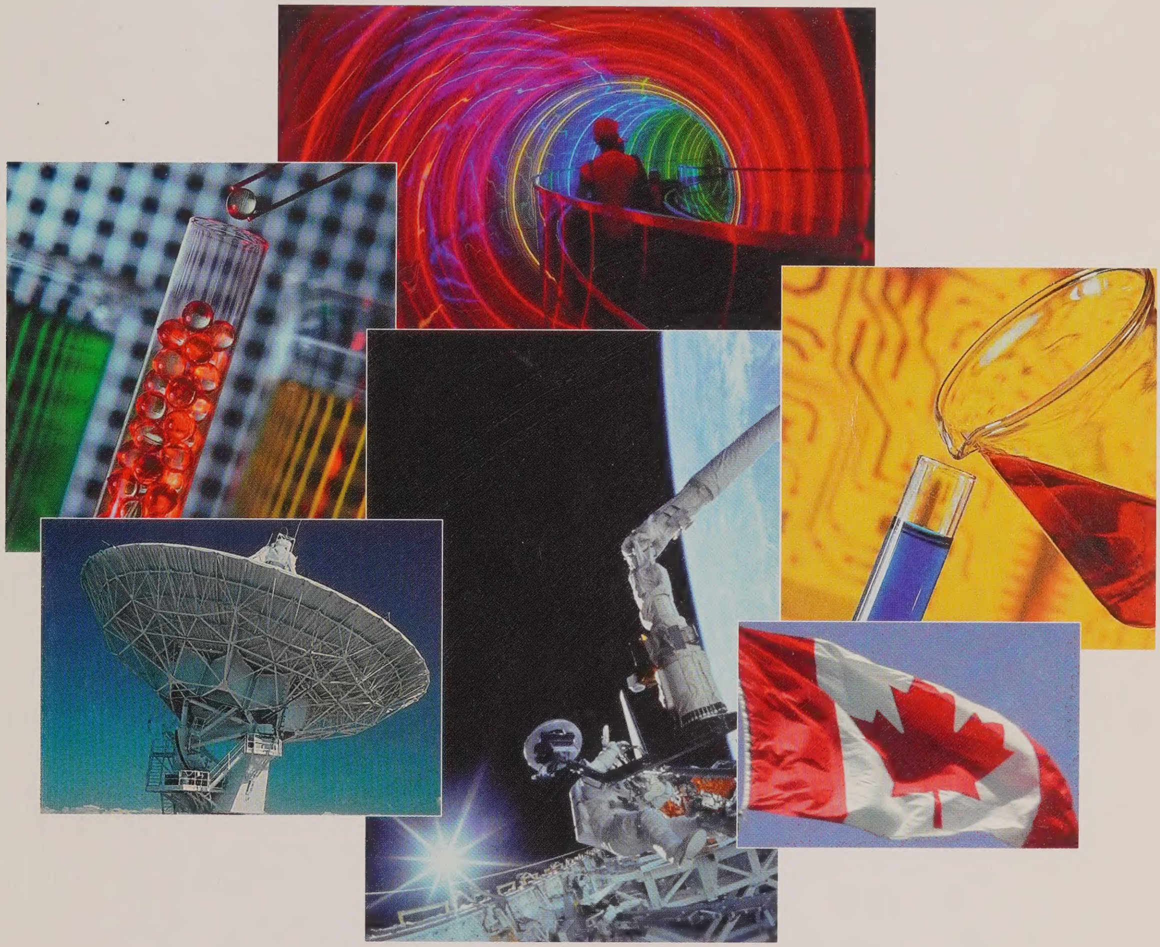
HOUSE OF COMMONS
CANADA

A Canadian Innovation Agenda for the Twenty-First Century

Fifth Report of the Standing Committee on Industry, Science and Technology



Susan Whelan, M.P.
Chair

June 2001

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has the honour to present its

FIFTH REPORT

Pursuant to Standing Order 108(2), the Standing Committee on Industry, Science and Technology proceeded to a study on science and technology policies. After hearing evidence, the Committee has agreed to report to the House as follows:

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CHAIR'S FOREWORD

In October 1997, the House of Commons Standing Committee on Industry began a long-term study leading to a series of reports on innovation, productivity and industrial competitiveness. This study was initiated in response to *Sustaining Canada as an Innovative Society: An Action Agenda*, a document written by several research groups for the Government of Canada and which had raised important questions on the quantity and quality of scientific research being undertaken in this country. The Association of Universities and Colleges of Canada, the Canadian Association of University Teachers, the Canadian Consortium for Research, the Humanities and Social Sciences Federation of Canada, and the Canadian Graduate Council described the situation as one of under-funding of basic research that presented a danger to Canada's long-term innovative capacity and, ultimately, to its citizens' standard of living.

In June 1999, the Committee answered the challenge laid out by these groups in its report, entitled *Research Funding: Strengthening the Sources of Innovation*, wherein it made 16 recommendations for improving the planning, effectiveness and efficiency of research activities in Canada.

Although the Committee was satisfied that this first report addressed the research and development (R&D) aspects of product and process innovation, it remained skeptical that R&D alone will solve all our industrial innovation problems. The Committee felt that competition is also an important ingredient of innovation. In fact, the Committee believes that competition is probably the single leading catalyst in all types of innovation and, unless it is present, R&D incentives proposed in this first study will be of little consequence. For this reason, the Committee next explored issues of productivity and competitiveness, which it believes are quintessential building blocks of a prosperous society. The Committee thus embarked on a second report that sought an optimal mix of all influential factors of innovation, in particular the merging of government plans and priorities concerning productivity and competitiveness with that of its R&D efforts in order to preserve Canada as a prosperous nation.

In April 2000, the Committee published its report, entitled *Productivity and Innovation: A Competitive and Prosperous Canada*, which contained 36 recommendations that will go a long way to revitalizing Canada's productivity and standard of living growth rates, hopefully enabling them to obtain levels recorded in the 1960s and thereby restore Canada's near-top world ranking. These recommendations will also better prepare Canadians and Canadian businesses for the opportunities and challenges presented by a knowledge-based economy.

Though it has been less than two years since the Committee began its foray into matters of innovation, a lot has transpired. In its 1999-2000 and 2000-2001 budgets, the Government of Canada responded to the Committee's recommendations in both reports

and, equally important, began addressing the public's concerns for policies geared to a knowledge-based economy. Government and private sector spending on R&D is now on the rise, and tax reductions are set in place to stimulate long overdue private sector investment. Not surprisingly, Canadians are witnessing improvements in Canada's Gross Expenditure on Research and Development (GERD) per unit of Gross Domestic Product (GDP) — the bell weather statistic for innovation in the longer term — and Canada's GDP, which has been growing in a non-inflationary way for more than a decade, is in fact setting a longevity record in terms of economic recovery since the 1990-1991 recession.

Federal government policy, particularly of the last two years, has provided a good start. The Committee — with its new name expanded from Industry to Industry, Science and Technology and now reflecting its broader mandate — feels that the time is right to re-walk this ground with a third report in order to provide the fine-tuning required for the next step in the federal government's innovation agenda, focusing primarily on science and technology (S&T) issues. In this way, the Committee will tie loose ends between R&D and productivity issues that were not addressed in its first two reports; more importantly, however, the Committee wants to ensure that these early positive economic results are not just a temporary spurt but the beginning of a long-term trend.

The Committee structured its hearings in such a way as to hear from as many experts as possible on S&T and its impact on a knowledge-based economy. The roundtable format chosen by the Committee allowed for a captivating debate of the principal issues at stake. These included: S&T contributions to a knowledge-based economy; R&D activities at universities and colleges, including factors that would accelerate the commercialization of their results; the government's R&D funding strategy with respect to the National Research Council, its Networks of Centres of Excellence, the three granting councils (i.e., Natural Sciences and Engineering Research Council of Canada, Social Sciences and Humanities Research Council of Canada, and Canadian Institute for Health Research), the Canada Foundation for Innovation (CFI), the Industrial Research Assistance Program (IRAP), Technology Partnerships Canada (TPC), Scientific Research and Experimental Development (SR & ED) tax incentives, and specific large and specialized R&D projects, including an evaluation of the "value-for-money" obtained in this strategy; financing innovative start-up companies; and the intellectual property rights and protection regime.

In the end, 43 expert witnesses appeared before the Committee. These Canadians clearly had a great deal to say about S&T, R&D, innovation and productivity, particularly as they applied to a knowledge-based economy. This evidence makes quite clear that Canada's industrious character needs to be complemented by a new and more pervasive innovation culture. Strikingly, the views of these experts were quite similar, or at least they were far less divergent than one might have expected. On the one hand, consensus on a number of issues that would be integral part of an innovation agenda was within the Committee's immediate grasp and this report reflects the in-depth knowledge and advice of Canada's experts in this area. On the other hand, the Committee uncovered what appears to be a number of problems permeating the processes of decision-making at the CFI, the granting councils and some federal research agencies. At

this time, I would like to thank those who participated in our extensive hearings process and for sharing their insights with us. I am confident that the public will agree that this report reflects both their concerns and common Canadian values and priorities in our ever-evolving and innovative economy. However, the Committee would also like it to be known that this report, because of time constraints, remains a piece of unfinished work. The Committee intends to pursue the concerns raised in this report in more detail this fall when we can call upon a wider selection of witnesses from amongst the S&T community and hopefully arrive at a broad concensus on any reforms left outstanding. This report, therefore, is the first in a series of reports that will help shape Canada's innovation agenda for the twenty-first century.

PREFACE

For most of this century the standard of living in Canada steadily and impressively improved in lock step with that of the United States; in fact, the economic growth rates of both countries averaged about 1.7% per annum in this period. Hence, Canadians and Americans, on average, are today more than four times richer than they were at the start of the twentieth century. However, Canada's most recent performance is troubling. Although productivity in both Canada and the United States was, to say the least, lethargic from 1973 through to 1990, a renaissance of American productivity and standard of living since that time has taken hold but has not crossed over to Canada. Canadians, on average, have thus suffered about a 20 percentage-point decline in productivity relative to the average American. The pre-existing "productivity gap" of about 10% between Canada and the United States at the end of the 1970s has thus widened to about 30%.

At this point, it is important to take stock of the fact that the unprecedented growth in material wealth and well-being throughout North America — and the Western World for that matter — for most of this century does not simply reflect a quantitative increase in the same goods and services. While history is marked by notable inventions — often coined a general-purpose technology — the greater wealth that we enjoy today is largely the result of new commodities, processed from new technologies, and made of radically different materials. Indeed, people living at the beginning of the past century would surely find today's marketplace to be made up mostly of goods and services that they could only dream about in their time. In some business sectors, today's economic reality is in fact running far ahead of these once distant "flights of fancy."

Sustained material wealth creation is more about working smarter and in new ways than toiling more intensively over longer working days surrounded by more machinery and equipment on a more spacious shop floor. Paradoxically, we are talking about change being a constant, that is, our methods of work should be in an almost constant state of flux, as we broadly incorporate the newest technologies, work rules, managerial processes and business organizational structures across the economy on a routine basis. This state of flux, however, must be sustainable and therefore managed, as Canadians are not automatons that can adapt instantaneously to new ways of work.

Canada is committed not only to maintaining but improving its high standard of living and quality of life. However, in today's increasingly globalized and knowledge-based economy, the country's reliance on its traditional strategies of exploiting our bountiful natural resources and in attaining maximum scale economies in production are no longer the key factors in assuring our competitive advantage. As has been amply demonstrated by very wealthy countries with limited natural resources and small populations, entrepreneurial people who successfully apply human and capital resources to science and technology (S&T) in an attempt to push forward the frontiers of knowledge and then disseminate, apply and commercialize this knowledge can create competitive advantages

in industry — Switzerland, Sweden, Norway and, more recently, Singapore and the Republic of Ireland come immediately to mind. So in a knowledge-based economy, a country's wealth and economic success is no longer found in the ground, in the size of the manufacturing plant, or in the horizontal and vertical industrial expanse of the corporate conglomerate, but in the minds and creativity of its people. Such a competitive advantage, however, can often be short-lived as rivals imitate and strive to catch up.

Innovation, as founded on S&T, has thus become the principal means for achieving economic success in the twenty-first century. However, such a demanding strategy, which will necessitate the development of a thoroughly comprehensive innovation culture throughout the business sector, will prove difficult for Canada, as Canadian businesses have historically been laggards in conducting R&D — the country's GERD-to-GDP ratio, or gross expenditure on R&D per unit of gross domestic product, has averaged 1.5% compared to the Organisation for Economic Co-operation and development (OECD) average of 2.2% over the past two decades. Rather than developing new technologies, products and services in an across-the-board way for most of the leading sectors of the economy, Canada has obtained a good deal of them through foreign direct investment, primarily from its southerly neighbour, and by other traditional means. These would include franchising, licensing, subcontracting and alliances, not to mention old-fashion spillover transfers as knowledge leaks out from a pioneering source, trained labour and managers subsequently switch employers, and through improved quality and reliability of inputs provided by local suppliers of the innovating company. However, as a number of interested observers have recently noted, the widening "productivity gap" between Canada and the U.S. — the country we have been relying so heavily on for a number of industrial innovations — is itself largely the result of a widening "innovation gap" between the two countries.

Canadian business culture must change and the Government of Canada must be the one to lead the way with: a sound innovation agenda, complete with specific objectives in mind; the establishment of challenging, yet realistic performance targets; and continuous benchmarking of innovation indicators against known world leaders. Furthermore, as a relatively mid-size economy, representing less than 1% of the world's population and not much more than 2% of the world's GDP, careful attention will have to be paid to just how much more R&D work is really economically wise, where Canada's R&D niches really lie, as well as the level of participation in cooperative international R&D ventures. Moreover, the diffusion of the invention, the creation of value and wealth, and the advancement of knowledge for reasons beyond commercial goals must always be kept in clear sight of public policy-makers. The Government of Canada's next step in its innovation agenda will indeed be pivotal and, more than any other public policy, will determine Canada's future course of productivity, standard of living and well-being.

LIST OF RECOMMENDATIONS

CHAPTER 1: SCIENCE & TECHNOLOGY CONTRIBUTIONS TO A KNOWLEDGE-BASED ECONOMY

Recommendation No. 1

That the Secretary of State (Science, Research and Development) design a new composite indicator of a country's investment in knowledge that goes beyond the current Organisation for Economic Co-operation and Development definition that includes education, research and development, and software. This should enable us to rank Canada amongst comparable countries of the world.

CHAPTER 2: THE INNOVATION RECORD

Recommendation No. 2

That the Government of Canada design and adopt a public policy instrument that specifically targets and encourages R&D-intensive industries to invest in Canada.

CHAPTER 3: THE CANADIAN INNOVATION SYSTEM

Recommendation No. 3

That the Government of Canada adopt science and technology policies to strengthen the components of the country's innovation system and to improve the linkages between its components.

CHAPTER 4: THE INNOVATION POLICY FRAMEWORK

Recommendation No. 4

That the Government of Canada target the number of scientific publications (per 100,000 population) and resident patent applications (per 10,000 population), which are surrogate measures of scientific discoveries and technological innovation, respectively, produced and processed each year in Canada. Canada's relative performance should be

benchmarked — and government policy should be assessed — on these terms against comparable countries of the world.

Recommendation No. 5

That the Government of Canada pledge its support and commitment to improved technology development and diffusion, particularly amongst Canadian small and medium-sized businesses.

Recommendation No. 6

That the Government of Canada review its current governance structure for federal science and technology and transform the Secretary of State (Science, Research and Development) to a Minister of Science and Technology responsible for overall federal science and technology issues and programs.

CHAPTER 5: STRATEGIC S&T INVESTMENT OPPORTUNITIES

Recommendation No. 7

That the Government of Canada develop a definitive advisory process for large scientific projects, particularly those with an international component.

CHAPTER 6: "VALUE FOR MONEY" FROM FEDERAL S&T SUPPORT PROGRAMS

Recommendation No. 8

That the Government of Canada improve the reporting of the Industrial Research Assistance Program's project results without disturbing the "business-like manner" in which the program is delivered.

Recommendation No. 9

That the Government of Canada immediately double its appropriations for an expansion of the Industrial Research Assistance Program.

Recommendation No. 10

That the Government of Canada substantially increase its appropriations for an expansion of the Technology Partnerships Canada program and

eliminate the one-third, two-thirds split between aerospace/defence and advanced enabling technologies of total funds invested from the mandate of Technology Partnerships Canada.

Recommendation No. 11

That the Government of Canada expedite the work of the National Research Council and the Canada Customs and Revenue Agency to align their eligibility criteria of research and development expenditures and modify the relevant tax regulations that would see eligible research and development expenditures under the Industrial Research Assistance Program made de facto eligible under the Scientific Research and Experimental Development tax incentive program.

CHAPTER 7: FEDERAL RESEARCH AGENCIES

Recommendation No. 12

That the Government of Canada provide financial support to the National Research Council of Canada to implement an expanded innovation cluster strategy.

Recommendation No. 13

That the Government of Canada increase its financial support of the Canadian Space Agency to enable Canada to play a more significant role in national and international space science projects as part of its innovation agenda.

CHAPTER 8: THE GRANTING COUNCILS AND THE CANADA FOUNDATION FOR INNOVATION

Recommendation No. 14

That the Government of Canada work with the Canada Foundation for Innovation in developing and implementing conflict-of-interest rules and mechanisms regarding complaints and redress consistent with that of federal government agencies.

CHAPTER 9: THE INTELLECTUAL PROPERTY RIGHTS REGIME

Recommendation No. 15

That the Government of Canada commit to maintain the current intellectual property rights and protection regime, while adopting the policy position that any non-trivial extension of any aspect of this privilege requires a demonstration of its net benefits to society.

CHAPTER 10: UNIVERSITY RESEARCH, R&D COSTS AND COMMERCIALIZATION

Recommendation No. 16

That the Government of Canada analyze the direct and indirect research costs at Canadian universities and colleges. Based on this information, the Government of Canada and provinces negotiate a new funding agreement that would take into account direct and indirect research costs and also the differential between large and small universities and colleges.

Recommendation No. 17

That the Government of Canada, after consultation with the provinces, develop a comprehensive policy on the commercialization of university and college research that would include rules on disclosure, ownership of results and administration issues.

CHAPTER 11: FINANCING INNOVATION START-UP FIRMS

Recommendation No. 18

That the Government of Canada direct the Business Development Bank of Canada and the National Research Council of Canada to develop and implement a joint incubation/technology-transfer assistance strategy. The strategy should encourage private venture capital firms and labour-sponsored fund participation.

INTRODUCTION

Unquestionably, innovation is the link between science and technology (S&T) and both long-term economic growth and quality of life. The preponderance of evidence demonstrates that the principal difference between our economic well-being today and yesteryear is explained by the prevalence of new products, services and production processes in the economy.

Innovation is more simply defined as the process of developing and introducing new and improved products, services and production techniques into the marketplace, whereby these new production techniques may amount to a novel processing, assembly, inventory, distribution, managerial and/or organizational method — whatever the case may be. At the same time, this process of innovation is largely carried out by firms that interact with other parties to a country's "innovation system," which comprises institutions such as universities, research centres, government laboratories, education and training facilities, intellectual property rights and protection regimes, financial intermediaries, and networks for sharing of S&T information and results.

Unfortunately, the task of exploring the inner workings of an innovation system is not as simple as defining the system itself. Modern notions of innovation — how it occurs, what forces are at play and how they interact — typically emphasize the cumulative and interactive nature of the process. Experts in the field have thus discarded the traditional linear model of innovation, whereby the source of advancement and novelty begins with basic research (experimental or theoretical work that adds to fundamental knowledge) which leads to other basic research or to applied research before moving on to product development and commercialization. The circular feedback model of innovation, which appears to be the dominant view today, suggests that the innovation process is in fact much more complex than was earlier thought to be and as captured by the linear model. Accordingly, innovation has many sources and can occur at any of the stages from basic research to applied research, to product development, to production and to marketing.

This view of innovation complicates public policy-making immeasurably, because the principal economic spillover activities and the institutions from which they emerge are not immediately identifiable. In other words, focusing government funding on institutions engaged in basic research (universities, non-profit institutions, government agencies, etc.) is not sufficient. Effective S&T policy necessarily entails involvement in proprietary research in some industries, while forsaking generic research in others. Moreover, the correction of systemic failures stemming from institutional rigidities and insufficient collaboration and interaction within the system of innovation becomes equally as important as correcting market failures, such as an inventor's inability to appropriate all the benefits associated with his invention, if not more so. Again, and in other words, the establishment of a strong intellectual property rights and protection regime in and of itself will not "cut it." Effective incentive mechanisms involve not only general policy responses such as the creation of property rights as a means of privately appropriating the benefits

associated with innovation activities or the doling out of research and development (R&D) tax incentives to the private sector. They imply targeted policy responses such as government investments in innovation infrastructure and in the formation of cooperative public- and private-sector joint ventures, in all its various forms, for the riskier projects where a critical mass of expertise has been, or is likely to be, established in Canada.

In the final analysis, a knowledge-based economy demands that Canada's innovation system must not only get larger than it is at present, it must operate better and more effectively. Being flush with new money is not sufficient; the system needs careful attention as to where the citizen/taxpayer "gets the biggest bang for his buck." This is the task of this report. The Committee seeks to influence the federal government's innovation policy agenda with a view towards making Canada's innovation system more effective and efficient, while ensuring a fair and equitable allocation of citizen/taxpayer dollars consistent with our national priorities.

This report addresses these concerns and it does so in two parts. Part I, comprising four chapters, deals with the Canadian innovation system and policies for a knowledge-based society. Chapter 1 highlights the distinguishing features of a knowledge-based economy, in particular noting its focus on innovation, while ascertaining its S&T contributions. Chapter 2 reviews the world's innovation record, but mostly Organisation for Economic Co-operation and Development (OECD) member countries, and establishes Canada's relative ranking. Chapter 3 provides a detailed overview of Canada's innovation system, including most of its components and linkages related to the natural sciences and engineering disciplines. Finally, Chapter 4 provides salient facts on Canada's innovation policy framework.

Part II comprises seven chapters that focus on Canada's S&T policy instruments. Chapter 5 reviews selective strategic S&T investment opportunities for Canada, including a long range plan for astronomy, biotechnology, genomics, nanotechnology, the Neutron Facility, and the light source synchrotron project. Chapter 6 addresses the "value for money" obtained from federal S&T programs such as the Industrial Research Assistance Program (IRAP), Technology Partnership Canada (TPC), and the Scientific Research and Experimental Development (SR&ED) tax incentive program. Chapter 7 provides an overview of selective federal research agencies, notably the National Research Council of Canada (NRC), the Networks of Centres of Excellence (NCE), and the Canadian Space Agency (CSA). Chapter 8 looks at the Canada Foundation for Innovation (CFI) and the three granting councils, the Natural Sciences and Engineering Research Council of Canada (NSERC), the Social Sciences and Humanities Research Council of Canada (SSHRC), and the Canadian Institute for Health Research (CIHR). While generally supportive of their work and accomplishments, the Committee has a number of outstanding concerns on their decision-making processes. Chapter 9 highlights important aspects of Canada's intellectual property rights and protection regime, while reviewing its interactions with competition policy. Chapter 10 considers the current and potential role played by Canada's universities and colleges covering issues with respect to the funding of indirect costs of research, the Canada Research Chairs program, and the prospects for commercializing university research work. Chapter 11 deals with financing issues of

innovation start-up companies and, finally, the Conclusion offers a summary of where Canada stands and where it is headed in terms of innovation; where the Committee believes Canadian policy should be directed; as well as a list of concerns the Committee intends to address in subsequent reports.

PART I: INNOVATION SYSTEMS AND POLICIES FOR A KNOWLEDGE-BASED SOCIETY

CHAPTER 1: Science & Technology Contributions to a Knowledge-Based Economy

CHAPTER 2: The Innovation Record

CHAPTER 3: The Canadian Innovation System

CHAPTER 4: The Innovation Policy Framework

CHAPTER 1: SCIENCE & TECHNOLOGY CONTRIBUTIONS TO A KNOWLEDGE-BASED ECONOMY

Towards a Knowledge-based Society

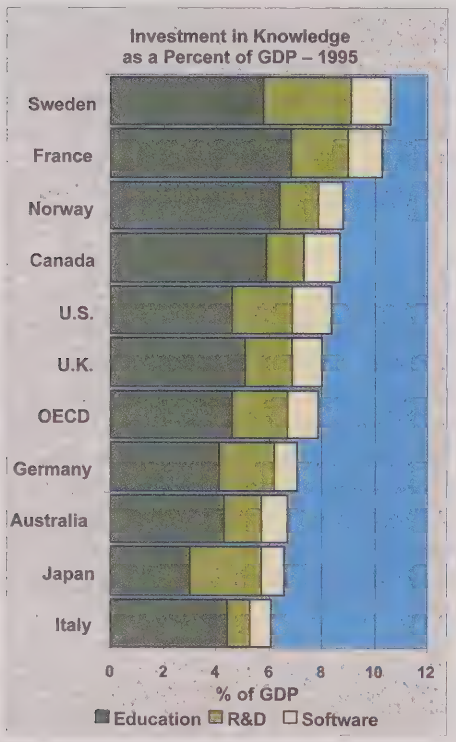
Beginning in the latter half of the nineteenth century, after substantial public investments had been made in railway and telegraph networks, large and more complex industrial organizations began to appear in Canada and elsewhere around the world. New advances in applied science, the increasing division of labour, and the emergence of a new managerial class promoted the growth of the modern industrial complex, as the corporation began to spread its activities both horizontally and vertically. These new technologies dictated massive investments in capital, as well as a commitment to building integrated production operations extending both backward into core raw material supplies and forward into marketing and distribution networks. In this way the corporation, bolstered by new financial instruments for funding growth, could realize the inherent economies of scale and scope in the new production methods, while securing the necessary returns on investment (i.e., organizational integration eliminated many hold-up problems in the value-creating chain).

The exploitation of these scale economies provided a great source of prosperity and, in fact, complemented the wealth creation that followed from the efficiencies obtained through industrial specialization with the opening up of international trade since the Middle Ages. Indeed, the new production processes emerging from the so-called *Industrial Revolution* led to the creation of many new industries at the same time as they considerably transformed many old industries. Unfortunately, the good came with the bad. The unprecedented cost advantages bestowed on large-scale operations benefited those who were first to transform their businesses in conformity with the new economic realities, while vanquishing the remainder. This provides us with a stark lesson on the importance of the business sector remaining nimble and flexible in face of profound social change.

In a sense of déja vu, yet another profound societal revolution is in progress that offers us as many economic opportunities and challenges, if not more, than did the *Industrial Revolution*. Today's source of societal change is characterized by the vast and substantive breakthroughs in science that have boosted rates of technical progress — manifest in both products and production technologies — over the past decade. These changes have accumulated in such numbers that people have seen fit to coin this transition period to a knowledge-based society as an *Information Revolution*; information technologies being the precursor of many further and far more advanced technological leaps forward to undoubtedly follow.

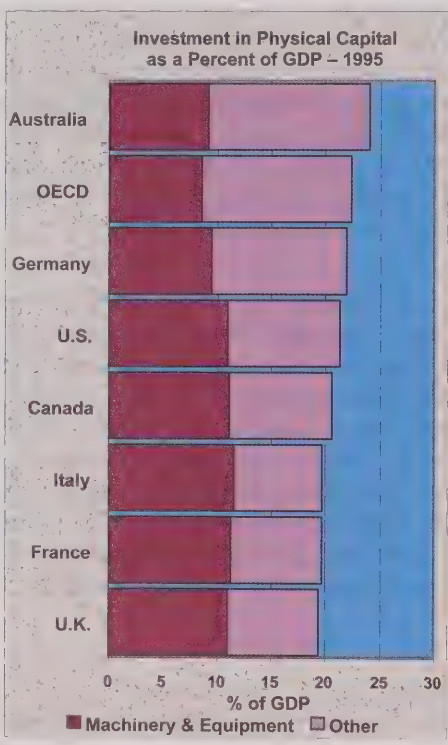
Knowledge, or "human capital," is the currency of these productivity gains, not physical capital or financial size or might, as dominated an industrial economy. Corporate managers, now under pressure to raise productivity through innovation rather than through economies of scale, have thus focused on designing lean production capabilities by downsizing their core activities; non-core functions and sub-assembly activities are today being out-sourced. The modern firm has also strived to de-layer its management hierarchies and replace them with multidisciplinary teams that take advantage of the diverse skill sets of its workforce. The successful business enterprise in this environment must therefore make sure that it out-sources peripheral capacity rather than knowledge; which, given its distinctive and "footloose" character, must vigilantly be sought, combined, integrated and maintained. This is the modern-day lesson that cannot be forgotten in the transition to a knowledge-based economy.

Figure 1.1



Source: OECD, *Science, Technology and Industry Outlook*, 2000.

Figure 1.2



Source: OECD, *Science, Technology and Industry Outlook*, 2000.

From the perspective of the country, rather than the firm or industry, the production, diffusion and use of information and technology are key to achieving sustainable growth in a knowledge-based economy. Not surprisingly, we are witnessing

firms and individuals spending more and more resources on producing knowledge. For example, Figure 1.1 demonstrates that investment in knowledge, defined narrowly, now represents 7.9% of OECD-wide GDP. Canada fares well on this score — investing about one percentage point more per year than does the typical OECD country — despite being a traditional laggard in terms of R&D activity levels. When we include private expenditures on education and training as an investment in knowledge, this figure would exceed 10% across the OECD.[1]

> *[K]nowledge is generated … in a number of forms. It does arise from the results of scientific research and experimental development. It is embodied in new technology. But this is not all of the knowledge that's important today in an innovative economy. Problem solving and the creative capacity of the workforce is also extremely important. The experience and technical skills of the workforce and the experience of management are also extremely important.* [Jayson Myers, Alliance of Canadian Manufacturers and Exporters; 13, 9:35]

Whether defined narrowly or broadly, this investment in knowledge remains less than half that invested in physical capital (see Figure 1.2), but now rivals investment in machinery and equipment, which was 8.6% per annum in 1995; though it should be understood that machinery and equipment, particularly that which is new and state-of-the-art, also embodies substantial knowledge. Nevertheless, when comparing Figures 1.1 and 1.2, it is evident that Canada has done a relatively better job in investing in knowledge than in physical capital in comparison to other OECD countries. If there is weakness, it lies in our R&D activity levels. The Committee recommends:

> **1. That the Secretary of State (Science, Research and Development) design a new composite indicator of a country's investment in knowledge that goes beyond the current Organisation for Economic Co-operation and Development definition that includes education, research and development, and software. This should enable us to rank Canada amongst comparable countries of the world.**

Innovation in a Knowledge-based Economy

With any revolution, whether industrial or informational, new products, technologies, firms and industries are created in relatively short order. A so-called "new economy" emerges, but its counterpart, the "old economy," which is composed of traditional industrial activities, does not simply fade away with time. The technical opportunities and challenges confronting these traditional industries vary and those that successfully respond carry on, although their activities will invariably change, both in their type and in the way they are organized. Obviously, those firms and industries that do not respond adequately to the challenge fail. For this reason, the Committee agrees with Dr. Baldwin that:

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1 On-the-job training, experience and tacit knowledge remain immeasurable.

> *It's inappropriate … to think about the world as divided up into that new knowledge-based economy, and by inference the old economy. There's innovation taking place in every industry.* [John Baldwin, Statistics Canada; 13, 9:11]

As any new knowledge will be useful in differing ways and amounts to different industries, technological winners and losers within and between various industries will emerge. The Committee was provided with some early results, as provided by several Statistics Canada studies and surveys. It appears that a large proportion of innovations are created in a few core industries such as the chemical, electronic, machinery, and instruments industries. Indeed, firms in this core sector are twice as likely to report innovations as firms in the other sectors.

The opportunities for innovation also vary across the spectrum of firm sizes, ownership nationality, and the degree of international market penetration — each forcing different methods of adaptation. For example, there is considerable specialization of function across different actors in the innovation process. The smallest firms report innovations at about half the rate of the largest ones, but they tend to be part of some innovation network involving large firms. The rate of innovation by multinational firms was considerably greater than for purely domestic firms. However, if domestic firms are also exporters, then they tend to innovate just as much as foreign-owned multinationals.

Innovation within the business sector has taken two general forms:

> *Innovations on the process side can be aimed at exploiting scale economies, or they can be directed primarily at improving the flexibility of the production process — by reducing economies of volume at a production line, by allowing the quick changeover of products, or by facilitating the more rapid customization of products. We find that the innovation process in Canada has its greatest impact on a firm's ability to respond flexibly to customer needs.* [John Baldwin; 13, 9:15]

Given the lack of pricing freedom with increasing foreign competition, either innovation strategy has become increasingly important:

> *Few companies today can afford, or have the luxury, to be able to pass higher production costs along to their customers in the form of higher prices. In fact, if you look back over the last 10 or 11 years since 1989, manufacturers' selling prices have on average increased by only about 20% … That's less than 2% per year. Yet there aren't very many costs of production that have increased by only that amount. Direct labour costs have increased by 45%. Costs of material have gone up by 52%. Energy costs have more than doubled and in fact have gone up by about 140% … much of that over the past couple of years. Capital costs have also increased by about 36%.* [Jayson Myers; 13, 9:40]

Although not without its difficulties in implementation, the solution to this perennial business conundrum is relatively straightforward:

> *The only way that companies can survive this cost squeeze is to increase productivity — in other words, to produce more of value for the value of inputs coming in to production. … They've been aiming to lower their unit production cost by removing overhead in almost every form possible, not only in inventories and non-core business activities but also by reducing waste, by reducing the time to manufacture and get the product to market, by reducing the space it takes to manufacture. In that process, automation and new business practices have been key. That's where knowledge feeds into that process.* [Jayson Myers; 13, 9:40]

Finally, the mere activity of innovation is itself biased in terms of labour requirements and aptitudes. Statistics Canada reports that innovation has tended to increase the demand for white-collar workers relative to blue-collar workers. Though this is not surprising, as we are constantly reminded that the quintessential resource of today's knowledge-based economy is human capital and explains the high rate of investment in education.

S&T Contributions to Innovation

Most people understand that R&D activities contribute to economic growth through the application of new technical knowledge to the development of new products and processes. These are the direct economic benefits of R&D. Industry advocates were quick to remind the Committee of this impact:

> *[T]he objective of science and technology policy should be to help encourage the translation of knowledge into value of some sort. Knowledge is fine for knowledge's sake, but if we're looking at contribution to the knowledge-based economy, what is important at the end of the day is how that knowledge is used.*
> [Jayson Myers; 13, 9:30]

They were also confident to predict a future very different from what we see today:

> *Manufacturing itself is changing around the world. We're going to see manufacturing that is based more on science — the science of machining, the science of materials, as well as the science of business organization and management, and new and revolutionary enabling technologies. We've seen the impact of information technology. Wait until you see the impact of where that's going with artificial intelligence, nanotechnologies, biotechnologies, micromachining, and new advanced sensors and materials. This is really going to revolutionize not only manufacturing but also the products we have, as well as the organization of manufacturing business.* [Jayson Myers; 13, 9:45]

Industry advocates also well understand that the benefits of R&D transcend the strict needs of the business community. Social objectives are important too.

However, R&D also has indirect benefits that probably far outweigh these direct benefits over the longer term. These indirect benefits would include: increased competencies developed by researchers and other people related to the research

process; and improvements in the “innovation system,” in part the result of more expertise and interaction amongst those working within this system. While these resources remain inputs to the innovation process, one witness clearly recognized them as outputs of R&D as well:

> *The outputs? Highly qualified people, real knowledge workers, people who are educated in basic research know the sources of knowledge around the world. … They understand what's being done. They know who are the people producing it, and they have networked with people of their own generation. ... But you also have highly skilled people being educated in project research. They can go to work in any sector, but they're particularly valuable to the companies that have been partners in supporting project research. These are students who know the business of those companies.* [Thomas Brzustowski, Natural Sciences and Engineering Research Council of Canada; 4, 9:30]

More specific R&D contributions to the economy were studied and reported:

> *We find … that the R&D process does indeed lead to innovation. Those firms that are doing R&D are far more likely to report innovations and the probability of this occurrence is relatively large. But we also find that the Canadian innovation system depends heavily on engineering knowledge and an ability to adapt advanced technology to production in Canada. In this vein, foreign multinationals play an important role since they provide a mechanism that allows for the licensing of technology transfer on a continuous basis. Other activities are combined with R&D facilities. Sometimes as complements, sometimes as alternatives.*
> [John Baldwin; 13, 9:20]

The data also suggest that being an R&D performer increases the probability of a firm reporting an innovation from about 10% to 40%. Furthermore, placing a heavy emphasis on technology, the production and engineering side of the firm, also increases the probability of a firm being an innovator by about the same number of percentage points according to Dr. John Baldwin of Statistics Canada.

These results are significant enough to make it worthwhile for the Committee to spend some time finding out where Canadian industry stacks up against the rest of the world in terms of R&D. Here, as noted above, the evidence is not encouraging:

> *Canada does not lead most OECD countries in terms of R&D spending as a function of gross output. This is not because firms ignore the R&D function in Canada. … While the R&D statistics show that over two-thirds were conducting some form of R&D, most of this activity was done only on an occasional basis. Far fewer firms conducted R&D on an ongoing basis, and even fewer conducted R&D on an ongoing basis in a dedicated facility.* [John Baldwin; 13, 9:20]

A relatively small group of innovators and specialized R&D performers thus characterize the Canadian economy and hand-in-hand with this structure is the development of research networks.

The Committee finds this situation a bit disturbing. When we combine the fact that Canada is importing most of its technological advances, rather than developing them here at home, thereby deriving the above-mentioned direct benefits of R&D, Canada is not fully capturing the many indirect benefits of R&D. This suggests that "freeloading" off foreign R&D is not in fact free; Canada pays in the form of lower value-added activities and lower skilled, lower paying job opportunities. Canadian industry is actually being stunted when not fully engaging in R&D, the primary input to innovation. Indeed, if we are as a country going to make a successful transition to a knowledge-based society, an "innovation culture" must be established in Canada. Attitudes must change:

> *The "culture of innovation" is not a commodity that can be purchased. It is acquired through action, participation and the collective will to succeed. It is to be hoped that the private sector, for its part, will follow the government's example and participate actively in our culture of innovation. The future of all Canadians, our collective well-being and our national pride depend on it. This explains our current efforts urging the private sector to join us in investing in research.*
> [The Honourable Gilbert Normand, Secretary of State; 9, 9:10]

The Committee concurs and believes this report's recommendations will in fact inspire and promote a progressive innovation culture within Canada.

CHAPTER 2: THE INNOVATION RECORD

Measuring Worldwide Innovation

Today's knowledge-based economy — although really still in its infancy — is a fast-paced one spurred by product and process innovation. Anecdotal evidence is all around us. Product lifecycles are becoming shorter and shorter all the time; for example, the average life of a personal computer model on the market today is no more than six months; for computer software, it is about six months; and for semiconductors, it is about one to two years. Even our more traditional products are undergoing rapid transformation. For instance, automobile models that used to last about a decade without major design changes are now being almost entirely revamped about every four to six years. The lifetime of a typical aircraft model has declined from about two decades to somewhat less than one. The same can be said about your standard utility services, like telephone and financial services, that have been complemented by an array of value-added features.

> *Innovation is taking place in every industry. The form this takes varies dramatically, from minor changes and products that are primarily cosmetic to the development of brand new products that are world firsts. Admittedly, at any point in time innovation may be more intense in some places. But in every industry, there are innovative firms that introduce new products and new processes, or both simultaneously.* [John Baldwin; 13, 9:11]

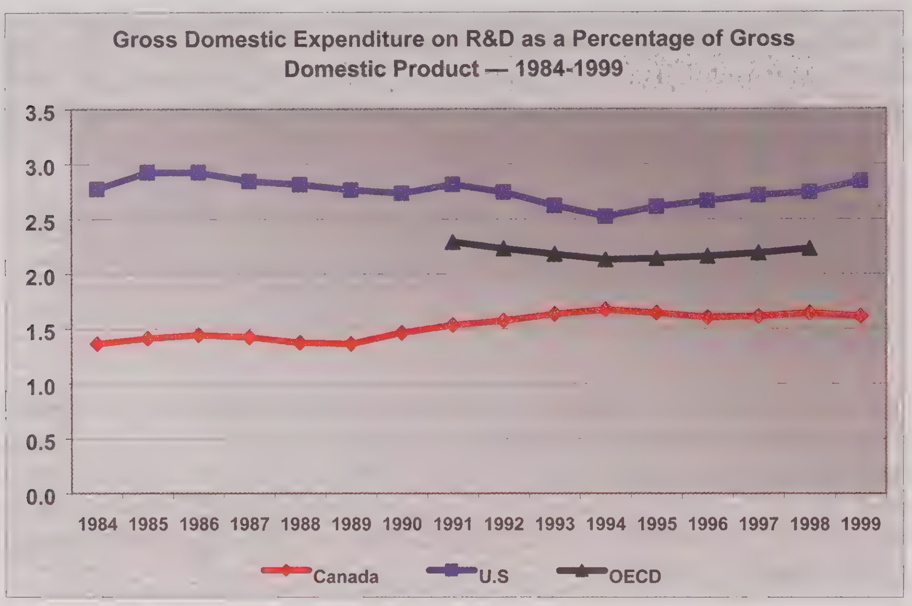
Not surprisingly, new information technologies resulting from the digital micro-processing revolution are often the dynamo driving many of these changes. However, this is not the sole source of change; major breakthroughs in genetics research, which are at the heart of the biotechnologies revolution, are increasingly altering the productivity and quality of our food and health systems. The Committee goes into greater detail on the futurist possibilities in Chapter 5.

Moving beyond this anecdotal evidence, the measurement of the speed of innovation within in any society is a more difficult undertaking. It is obvious to most people that as resources spent on producing more knowledge increase, so too does the rate at which we expand the frontiers of knowledge (scientific discoveries, inventions). However, it is less obvious to most that the efficiency of the entire "innovation system" also positively influences the speed of innovation. Part of the problem stems from the fact that, for S&T activities, it is far harder to measure output than input. Whereas an input such as R&D can, in general, be measured in monetary terms or by "head counts," the valuation of output is fraught with difficulties because: (1) it is more diverse; (2) it is often obtained indirectly or is embodied in a wider array of product and service packages that are priced as a bundle; and (3) it is sometimes without any monetary counterpart due to the lack of an active marketplace, such as for many environmental, health and education goods and services.

[I]nnovation is heterogeneous. Innovation consists of different types of outputs. Innovation intensity differs across industries, and it differs across actors. There's no single dimension that dominates others, but there are some that are more important than others. [John Baldwin; 13, 9:11]

In this case, standard procedure has been to use an output of R&D to substitute for the real output of innovation. Scientific publications and patents, which are really intermediate inputs to innovation, are thus used as surrogate measures of scientific discoveries and new technologies, respectively, but caution should be observed, as they are really partial and imperfect indicators.

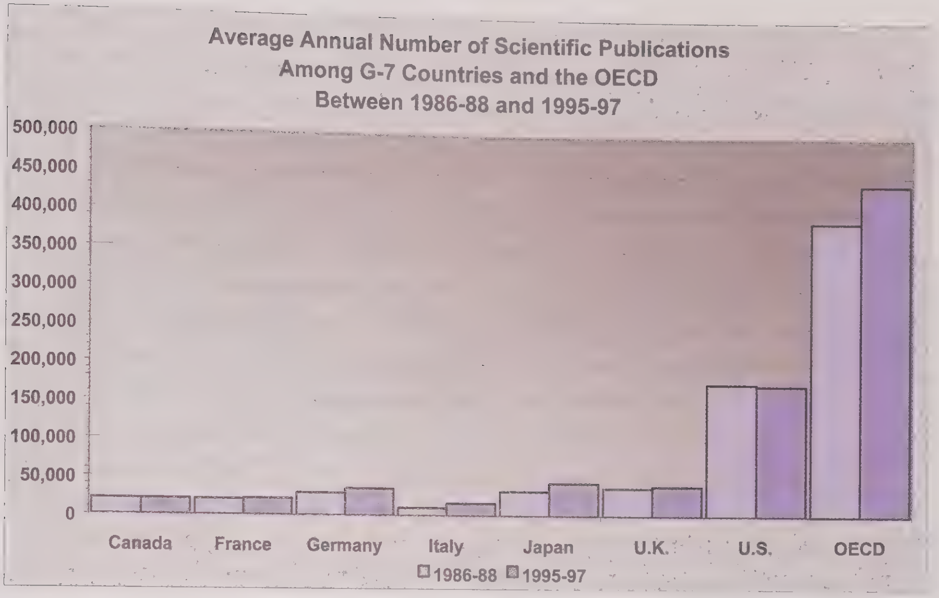
Figure 2.1



Source: OECD, Main Science and Technology Indicators, No. 1, 2000.

The Committee will first deal with the inputs to innovation and will next move on to the efficiency of the innovation system. In terms of inputs, gross domestic expenditure on R&D (GERD) as a percentage of gross domestic product (GDP) remains the best indicator. Figure 2.1 displays this R&D input for Canada, our toughest competitor country (the United States), and the OECD over most of the past two decades. The figure indicates that relative R&D funding across OECD countries shows no discernible trend, upwards or downwards, fluctuating about 2.2% of GDP. In absolute terms, this expenditure amounted to US$518.3 billion (using the OECD's purchasing power formula to consolidate it in one currency) in 1998. Canadian and American performances mimic that of the OECD, though their averages are different: 1.5% of GDP for Canada and 2.8% for the U.S.

Figure 2.2



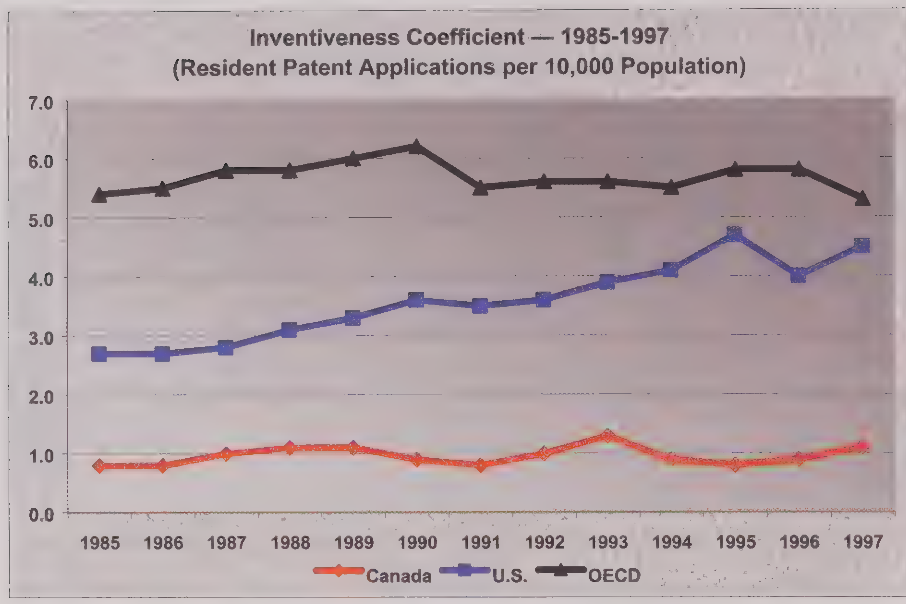
Source: OECD, Science, Technology and Industry Outlook, 2000.

In terms of research outputs, the Committee will first deal with scientific discoveries as estimated by scientific publications, followed by technological inventions as estimated by patent applications.

Each new scientific publication holds the promise of expanding some frontier of knowledge. Yet only an increased number of publications on an annual basis offers the prospect for an increased rate of knowledge production and, indirectly, a faster speed of innovation (assuming for sake of simplicity that each article yields a similar benefit to society). As such, Figure 2.2 indicates that the annual number of scientific publications, estimated at 438,966 between 1995-1997, is relatively unchanged from 1986-1988 in most G-7 countries, Japan being a slight exception. Only the smaller economies of the OECD are showing signs of raising the productivity in their research activities. The Committee must therefore conclude that the efficiency of the scientific community has not changed; both outputs and inputs of scientific knowledge are roughly the same between the 1980s and 1990s.

In terms of technological innovation, Figure 2.3 tracks the OECD's Inventiveness Coefficient, defined as a country's resident patent applications per 10,000 population, between 1985 and 1997 for Canada, the U.S., and the OECD. This indicator of an innovation system's efficiency also suggests a rather flat performance across the OECD, including Canada, with the United States improvements offsetting other OECD country deteriorations — though the latter conclusion may be premature.

Figure 2.3

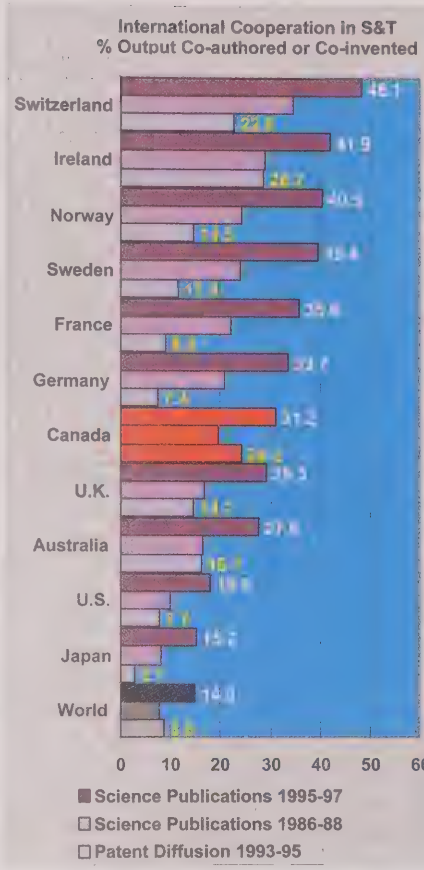


Source: OECD, Main Science and Technology Indicators, No. 1, 2000.

Given the apparent diverging U.S. performance in terms of resident patent applications with that of other OECD countries for such a long period, more scrutiny of the results is warranted. It must be noted that, in the early 1980s, several U.S. Federal Court initiatives and decisions bolstered the U.S. patent system, along with legislative changes that expanded patent eligibility to include software, business practices and higher lifeforms. These Court initiatives not only unified the judicial treatment of patent rights across the country, they transformed the legal environment from one that was generally sceptical of patents to one that promoted the broad exclusive rights granted to patent holders. The Court also made it more difficult to challenge a patent's validity by raising the evidentiary standard, along with showing a greater willingness to grant preliminary injunctions to patentees during ongoing infringement suits. Hence, the observed greater propensity to patent in the U.S. may not then be the result of some greater R&D productivity, but rather is an indication that the pro-patent court initiatives triggered a "patent race" in the United States. The motivations for such a race could be twofold: (1) the larger companies of industries characterized by cumulative product and process innovation, such as the semiconductor, computer hardware, machinery and equipment, electronics, etc., were "harvesting" their past research more intensively to use them strategically in the negotiation of use rights with other holders of complementary patents; and (2) small, innovative start-ups across all industries required patents to obtain venture capital on better terms, or to obtain these funds when they otherwise could not. These possible explanations further corroborate the need to show caution when using these measures as indicators of innovation. Indeed, the quality of each patent claim likely declined with the more intensive harvest.

In summary, based on both the amount of inputs devoted to R&D and the efficiency of their use within the R&D activity across the OECD, the evidence suggests that there has been no increase in the speed of innovation throughout the 1990s. R&D inputs and the ratio of R&D outputs to R&D inputs are unchanged in the last decade across the OECD. The anecdotal evidence to the contrary implies that there must be other external factors at work. As such, the Committee draws on its observation that the globalization phenomenon is pervading most other business activities and turns to evidence of increased international diffusion of innovation and research cooperation as a possible explanation for the perceived increased rate of innovation.

Figure 2.4

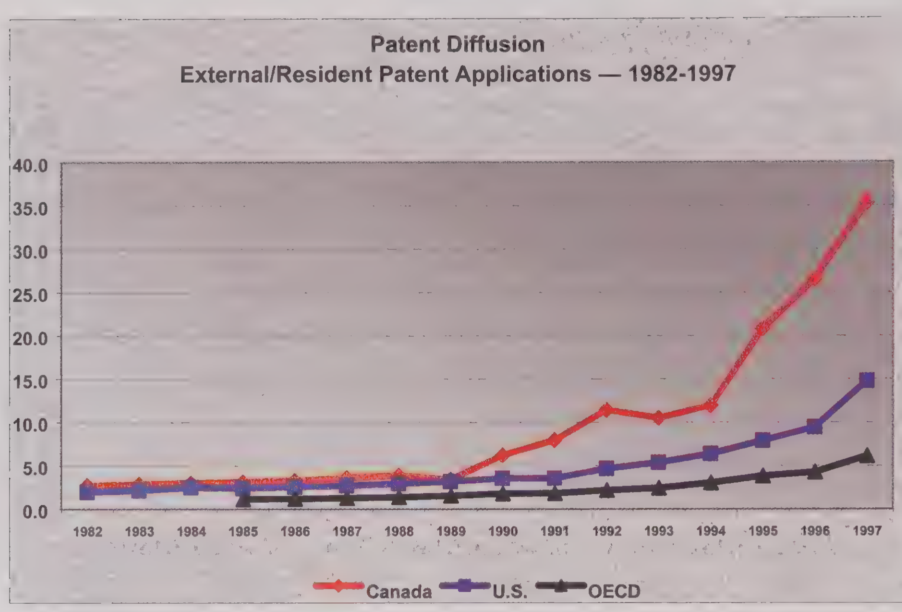


Source: OECD, *Science, Technology and Industry Outlook*, 2000.

Figure 2.4 provides us with some indication of the increased international cooperation in the S&T research community. Throughout 1995-1997, scientific publications across the world listing a foreign co-author averaged 14.8%, up from 7.8% in 1986-1988. In other words, this type of cooperation more than doubled in less than a decade. While surpassed by most continental European countries, Canada — with 31.2% of its scientific publications citing a foreign co-author — places well on this measure of international cooperation; it is more than twice the rate around the world. In terms of patents around the world, 8.8% cited a foreign co-inventor in 1993-1995. Again, Canada places well above the world average — some three times higher — and is only surpassed by Ireland.

The number of national patents filed in OECD countries each year between 1985 and 1997 has increased at an average annual compound rate of 14.3%; yet applications by residents of each country increased only at a rate of 2.5% in this period. This suggests that patentees are increasingly applying for protection beyond their domestic borders and the statistics confirm the above inference. The OECD reports the patent dependency ratio (non-resident-to-resident patent applications) throughout the OECD has increased from 0.99:1 in 1985 to 3.16:1 in 1997, while the rate of diffusion of patents (external-to-resident patent applications) within the OECD, as shown in Figure 2.5, increased from 1.8:1 in 1985 to 6.15:1 in 1997.

Figure 2.5



Source: OECD, Main Science and Technology Indicators, No. 1, 2000.

Figure 2.5 also demonstrates that Canada has, more than the U.S. and the OECD countries, on average, been at the forefront of this globalization wave. Perhaps these international cooperation performances provide the statistical evidence in support of anecdotal evidence of an increased rate of innovation, at least as is perceived by Canadians. If this conclusion is indeed correct, each country's innovation system has on average remained the same — though it may be more specialized — and the acceleration in innovation is due solely to efficiency gains resulting from the S&T community going global.

Ranking Canada's Innovation Performance

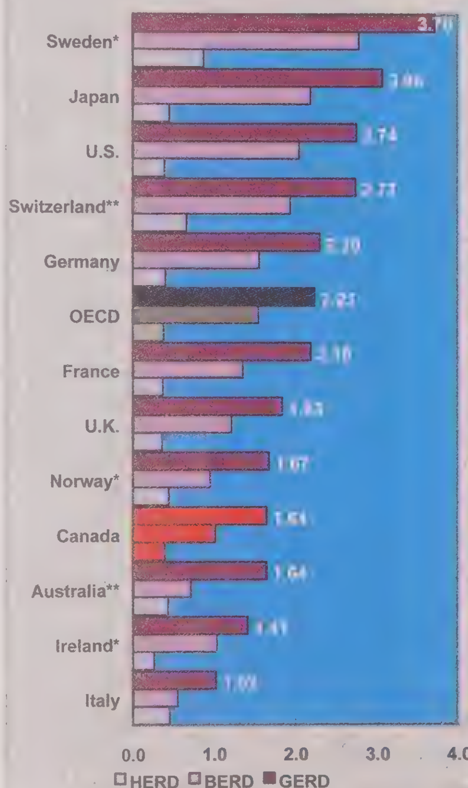
Canada's innovation record, as was shown in many of the previous section's graphs, has been steady and is by and large unchanged — as has been the case for most OECD countries. These graphs offered a time profile of our innovation system's performance from the late 1980s through the 1990s. In terms of R&D as a percentage of GDP, in terms of scientific publications, and in terms of the resident-patent-applications-to-population ratio, the status quo has been maintained. Except in terms of international cooperation, Canada's innovation system at the turn of the twenty-first century is much as it was in the 1980s.

In this section, the Committee would like to ascertain Canada's relative position or rank within the OECD. Again, the principal indicator of inputs into the innovation system is GERD per GDP dollar. Figure 2.6 places Canada ninth among the 12 OECD countries considered. With a GERD-to-GDP ratio of 1.64%, Canada is well below the OECD average of 2.23% in 1998. Although tied with Australia, Canada outperforms only Ireland and Italy. Finally, R&D conducted by the business sector (BERD) and higher education facilities (HERD) show similar performances and rankings.

What to make of Canada's relatively poor R&D position has been a perennial concern of many commentators in the past. This Committee will only remark on a couple of observations. First, while large economies such as the United States, Germany and Japan are expected to rank near the top because they can spread these overhead costs more widely than other countries, it is surprising that Sweden, the top-ranked performer, and Switzerland placed so well. This suggests that, while the size of an economy is a positive factor in encouraging R&D, the lack of economic size does not form an insurmountable barrier to being a successful R&D performer. Second, a common characteristic of those situated at the top, except the U.S., is that they are geographically small countries, suggesting a relative lack of natural resources. This scarcity has necessitated the pursuit of economic strategies almost diametrically opposed to that of Canada, which is to exploit its comparative advantage in natural resources. These smaller countries have instead pursued a strategy of comparative advantage in innovative industries requiring bountiful investments in R&D and human capital. In the end, Figure 2.6 clearly demonstrates that should Canada decide to shift its strategy of comparative advantage from natural resource industries and towards innovative and knowledge-based industries, the only thing standing in the way is the country's will.

Figure 2.6

Domestic Expenditure on R&D by Perfoming Institution as a % of Gross Domestic Product in 1998



Source: OECD, Main Science and Technology Indicators, No. 1, 2000.

Other commentators have also noted the implications of these contrasting economic strategies. To effectively exploit its natural resource bounty, Canada has

required considerable capital — the natural resource sector is very capital intensive both absolutely and relatively — making its importation critical. Foreign capital dependency translates into an economic structure characterized by many foreign-owned manufacturing plants and this has implications for Canada's relative R&D performance and ranking.

> *I offer a word of caution … It's widely known that R&D is not done intensively in Canada. The ratio of R&D expenditures to GDP is lower in Canada than in many other OECD countries. But that does not mean our industry lags behind other nations in terms of our ability to benefit from the knowledge gained from R&D. We have to recall that over half of Canadian manufacturing industries are foreign owned, and foreign-owned plants in Canada benefit from the R&D done abroad by their parents. Indeed, if you take into account both domestic R&D spending and what our plants pay for R&D done abroad, Canada increases its R&D ranking substantially.* [John Baldwin; 13, 9:25]

The structure of one's industrial sector has other implications for cross-country comparisons of the GERD-to-GDP ratio:

> *It should be noted that comparison on simple R&D to GDP ratios across the country is also misleading if corrections are not made for the different industrial structures of countries. Innovation regimes differ across industries. Studies have shown that there are some industries, like electronic industries and machinery, … they're at the core of the innovation system. They do a large amount of R&D and they produce more innovations ... Others, such as food products use new materials and machinery from the core sector and tend to expend money not on R&D, but technological and engineering, and production systems. The two sectors work together in a symbiotic relationship. … Some countries have more of the former, other countries have more of the latter, and those countries such as Canada that concentrate more on the latter will simply have low R&D ratios because of that, even if they have a highly innovative industrial sector.* [John Baldwin; 13, 9:25]

This suggests that Canada's poor business R&D performance is not necessarily a cause of any innovation problem the country may have, but is a symptom our industrial structure being focused — and probably too focused — on exploiting its natural resource base. This view is somewhat corroborated by an OECD study that indicates that Canada was unique among the OECD in that its increase in R&D intensity across its business sector in the 1990s was due almost entirely to a shifting industrial structure towards high-technology industries, whereas the R&D-intensity changes (some positive, some negative) of virtually every other country of the OECD were within-industry effects.[2] Canada's industrial structure has thus been undergoing more change than other countries in the 1990s.

For these reasons, there is a danger in policy-makers being too focused on input measures of innovation such as R&D:

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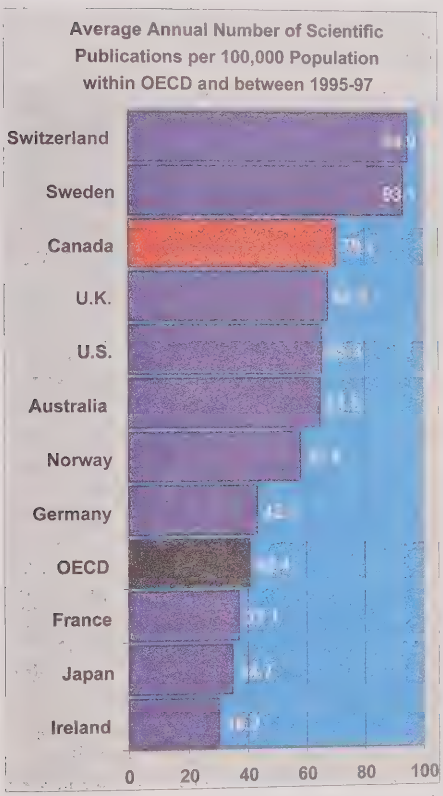
2 OECD, *The Knowledge-Based Economy: A Set of Facts and Figures*, 1999, p. 14.

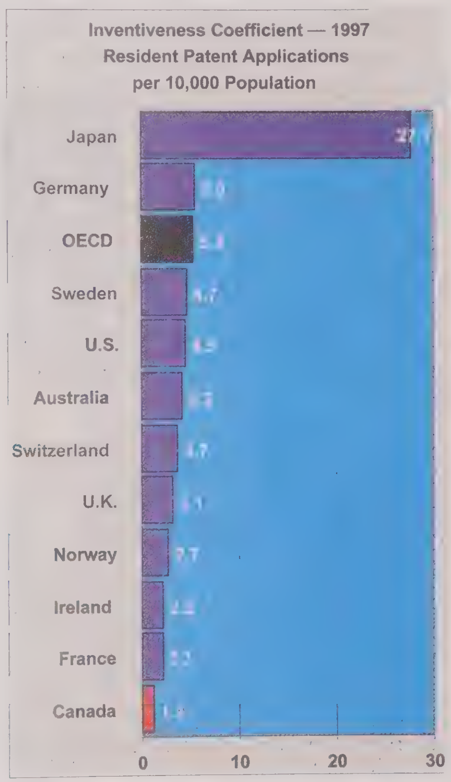
[W]e should always be cautious about using input measures like R&D to GDP ratios … when we come to evaluate ourselves against other countries. After all, the ratio of R&D to GDP is the ratio of an input to total output. It's not obvious that we want to try to maximize the ratio of inputs to outputs. Do we want to try to maximize the amount of transportation expense we have, or the amount of labour we have? If we did, of course that would mean we'd want low labour productivity ratios ... We really want to maximize the output of the process relative to the inputs, or minimize the ratio of an input to an output. In some sense, having a strong prosperous economy that accomplishes much with less, including R&D, should be out ultimate goal. [John Baldwin; 13, 9:25]

Figure 2.7



Source : OECD, Main Science and Technology Indicators, No. 1, 2000.

Figure 2.8



Source : OECD, *Main Science and Technology Indicators*, No. 1, 2000.

Moving on to R&D outputs such as scientific discoveries and technological inventions, the Committee again uses their surrogate measures, scientific publications per 100,000 population and resident patent applications per 10,000 population, respectively. Figure 2.7 ranks Canada third among the 11 OECD countries considered in terms of the number of scientific publications. Canada is a top performing S&T country; apparently, Canada has distinguished itself in clinical medicine and biomedical research.

Figure 2.8, on the other hand, places Canada in last place of 11 OECD countries in terms of resident patent applications, and thus reinforces Canada's poor R&D showing. However, the Committee was again cautioned against making too much of these statistics:

> *While R&D is not done intensively in Canada — and the R&D ratios are often quoted as indicating we have major problems — this should not be interpreted to mean that the Canadian scientific community is in some sense ineffective. There's ample evidence showing that Canadian universities that engage in R&D have a very successful output and that the number of papers produced and the number of patents are all relatively high when compared with the number of people in universities. You can use the same yardstick to judge the effectiveness of R&D in Canada. If we create an index of the number of patents taken out in U.S. markets per R&D scientist in the home country, and calculate such a measure for Canada and most European countries, we sit right in the middle of the pack. Our R&D scientists are relatively effective.* [John Baldwin; 13, 9:25]

These data only confirm the Committee's view that it is not the level of R&D *per se* which will determine our innovation capabilities; rather it is the management of the limited R&D we do undertake which is particularly important and has had the greatest impact on the pace of innovation. However, as we alluded to in Chapter 1, Canada is missing out on the many indirect benefits of R&D because of low R&D activity levels and, as suggested in this chapter, lower R&D levels may be the result of an anomalous industry structure; it should be noted that this structure is currently undergoing significant change for the better. With a view to increasing the rate of change in Canada's industrial structure towards one that is consistent with a knowledge-based economy, the Committee recommends:

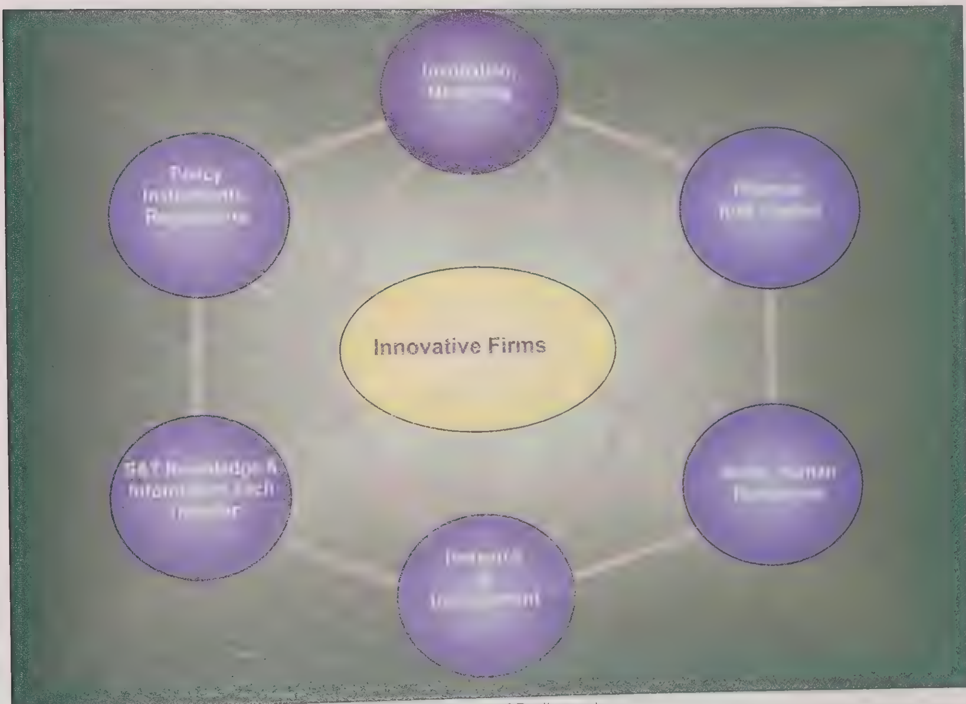
2. That the Government of Canada design and adopt a public policy instrument that specifically targets and encourages R&D-intensive industries to invest in Canada.

CHAPTER 3: THE CANADIAN INNOVATION SYSTEM

Knowledge Sources and Flows

The Committee has thus far provided a simple definition of an "innovation system" and has, in passing, mentioned it both in terms of the national and local context — in the case of the latter, more formally referred to as a geographically based sectoral cluster. Clarity demands more precision from the Committee and, indeed, it is now time to put "a little flesh on these bare bones."

Figure 3.1
Economic Elements of an Innovation Cluster



Source: National Research Council of Canada and Library of Parliament.

The Committee will not diverge from the term "innovation system" as provided by the experts appearing before it. The Canadian innovation system — a term used to describe both our S&T institutions and their various linkages — creates, disseminates and exploits the knowledge that fuels a productive economy, which, in turn, makes a prosperous society possible. To function effectively and to realize these social objectives, this system depends on the complementary strengths of three key sectors: the private sector, universities and other not-for-profit institutions, and governments. Each of these

sectors has a unique role to play in the system but, in terms of the federal government, it has subsequently identified and assigned itself a dual role of performer and facilitator of research. It fulfils these roles both by performing research, using intramural capabilities and facilities, and by funding extramural research and fostering partnerships among the various research-performing sectors. As such, innovation systems are essentially national in orientation because national institutions finance and equip them, but they are largely organized and executed at the local level. Canada's national innovation system thus comprises a number of geographically concentrated sectoral clusters devoted to innovation. Such clusters have several economic elements (see Figure 3.1).

Figure 3.2
Canada's Innovation System

Source: Thomas Brzustowski, NSERC; Statistics Canada, Library of Parliament.

The Committee was provided a series of detailed diagrammatic representations of Canada's innovation system and its various components and linkages. Though this personal project of Dr. Thomas Brzustowski was described as a "work in process," it is already sufficiently complete and accurate in portraying important parts of Canada's innovation system for the purposes of this Committee. With the modifications made by the Committee, the average layperson should equally find the next three diagrams both insightful and quite self-explanatory.

Beginning with Figure 3.2, a slightly modified version of that presented to the Committee, Canada's innovation system is situated in an environment that is best characterized by five flows of knowledge. These sources embody knowledge differently and make distinctive contributions to the Canadian society and the world. The sizes of these arrows try to capture the relative sizes of flows of the different sources of knowledge in 2001, though not exactly (percentages are indicative of the relative inflow-to-outflow of the source, where information is available). The five flows of knowledge are: (1) codified knowledge; (2) tacit knowledge of migrants; (3) tacit knowledge found in foreign direct investment (mostly by multinational enterprises (MNEs)); (4) innovations; and (5) commodities. The last two knowledge flows are found in products and services, which are broadly distinguished by their relative availability from various sources and principal price-determining mechanisms, such as price-setting in the case of innovations and price-taking in the case of commodities.

The first flow of new knowledge, codified knowledge found in books, academic and trade journals, manuals, etc., results from research that Canadian residents undertake. Canadian universities, Canadian government labs and Canadian industry are responsible for about 4% of this knowledge, so the lion's share of about 96% of new knowledge arising from original research comes from elsewhere in the world. In this context, research is defined as original research and, therefore, does not include, for example, the knowledge a student obtains from his research efforts at a library.

Although it is generally argued that this knowledge is a public good in the original sense of the term — there is no rivalry in its consumption and, therefore, one's use of it does not prevent someone else from using it as well — a pre-existing stock of knowledge is required for any novel addition to be of any use.

> *The interesting thing about knowledge, of course, is that if there is a supply of new knowledge out there, the fact that you're using it doesn't make it any less available for somebody else. ... But to get at it you need to understand it. If you don't understand it, the book is closed. It's not accessible.* [Thomas Brzustowski; 4, 9:15]

Moreover, a basic understanding of the new knowledge is only one element of the value-creating equation. A solid innovation infrastructure is also required to put this new knowledge to work:

> *[K]nowledge is a global resource. Of course it's extremely important to make sure that we have a strong innovation infrastructure here in Canada, but it's also important to focus on the ability of Canadian companies to access knowledge, access skills, access technology from around the world.* [Jayson Myers; 13, 9:35]

There are also two sources of tacit knowledge: one embodied in the in- and out-bound direct investments of MNEs, the other embodied in people. In terms of the first source, knowledge is embodied in the capital machinery and equipment, the blueprints of the plant layout, and in the organizational structure of an MNE or a domestic company that licenses, franchises, subcontracts, sells or allies with foreign companies. Canada has historically been a net importer of foreign direct investments (FDI), but since 1997 has become a net exporter of direct investment (i.e. flows, not stocks). In terms of the second source, it was summed up by one expert:

> *We also have flows of … "tacit" knowledge, the knowledge that people have in their heads and in their hands, which they bring with them. They bring it with them when they immigrate to Canada. They take it with them when they emigrate from Canada.* [Thomas Brzustowski; 4, 9:10]

It is widely known that Canada has been a destination of net migrant flows of people since before its confederation, but what is not always recognized is that the knowledge content of immigrant-emigrant flows has always favoured Canada. More knowledge, as indicated by the years of schooling and diplomas/degrees obtained, enters Canada than leaves Canada each year. The so-called "brain drain" is decidedly smaller than the "brain gain," though care should be taken when using even the official data because the schooling systems and the quality content of their grading classifications are not equivalent around the world. Moreover, not all highly educated immigrants to Canada qualify for employment in their area of expertise according to the professional licensing boards, thus leading to the newly-coined "brain waste" category.

> *There's one more flow of highly qualified people … These are people who come in and who are not allowed by various restrictions to practise their professions in this country. If there's brain drain, there's also brain waste, and this is it.* [Thomas Brzustowski; 4, 9:15]

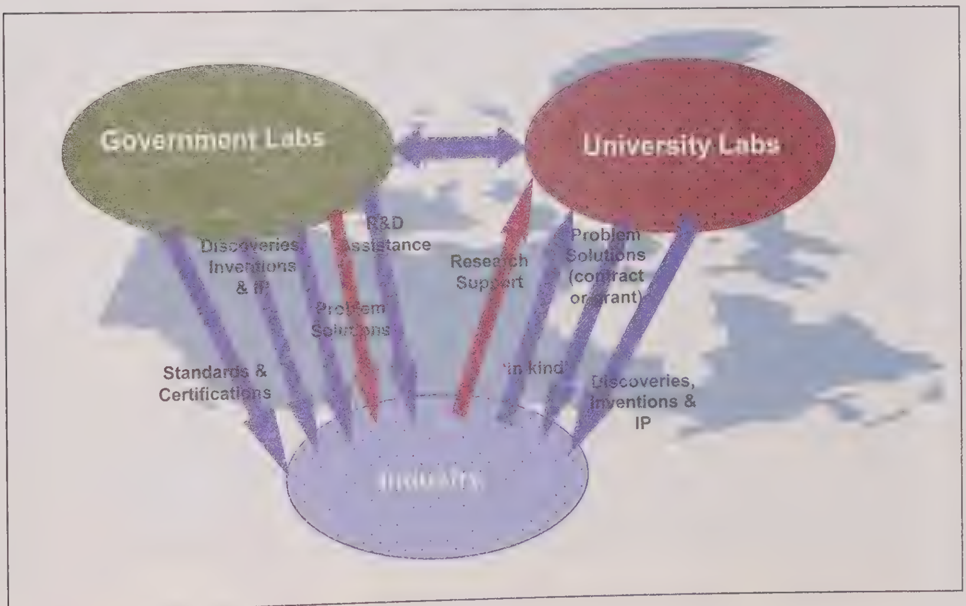
Finally, products and services embody knowledge. They can be divided into commodities and innovations. Commodities are defined as those products and services that are widely available from a number of sources on like terms and conditions (i.e., somewhat equal functionality and quality). Consequently, their producers are price-takers in competitive markets (and sometimes quasi-price-takers in regulated markets in terms of telephone, cable television, railway, airline, banking, insurance, auto leasing products and services, etc.). Innovations are defined as products and services that are not commodities. They are available from only a limited number of sources, often not on the same terms and conditions. For example, videoconferencing services are a recent innovation, but a VCR, while being an innovation in the 1980s, is no longer considered as such. New fashion apparel is an innovation, paradoxically even when it may in part be a copycat version from a previous generation. A telephone directory, while usually

considered by most as a commodity to the extent of being an almost stale product or service (except for update portions), when first made available on the Internet was an innovation. Time thus eclipses most innovations, turning them into commodities, and the novelty of their embodied knowledge ages with them.

The Government-University-Industry Research Triangle

Moving from the general to the specific, Figure 3.3 identifies important flows entwined in the Government-University-Industry research triangle (the colour scheme of flows as represented by arrows matches that of Figure 3.2 and 3.4 and, in this case, blue represents codified knowledge and mauve indicates an investment). Beginning with research undertaken at government laboratories, some of this activity is conducted under contract to provide solutions to specific problems that have been defined by the sponsoring company. University research also engages in this activity, sometimes further supported by government grants. There is also a flow of discoveries and inventions from both government and university research labs to industry, with the accompanying potential or actual intellectual property. R&D assistance often takes the forms of both knowledge and financial support, particularly to small and medium-size businesses (i.e. IRAP — Industrial Research Assistance Program).

Figure 3.3
The Government-University-Industry Research Triangle



Source: Thomas Brzustowski, NSERC; Library of Parliament.

University research sometimes receives support from industry, both “in cash” and “in kind,” that often includes proprietary knowledge held by industry. Government research also provides standards and certification, often addressing issues such as drug approval, automobile safety, building codes, “green” labelling, etc. Finally, there is also an active interchange of knowledge among university and government researchers, often with complementary objectives and facilities.

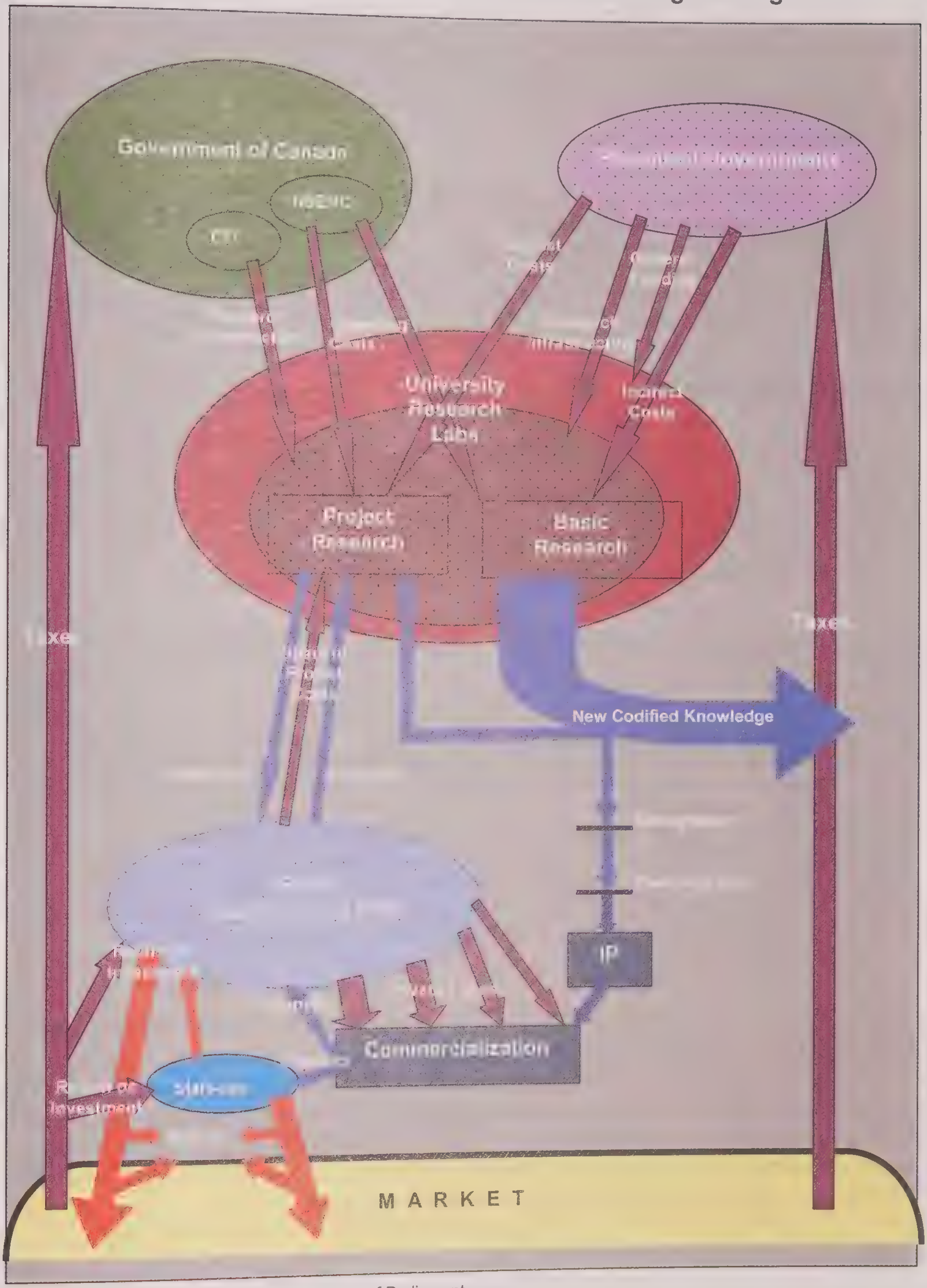
The Natural Science and Engineering Innovation System in Canada

Although quite intricate, the Government-University-Industry research triangle does not completely capture Canada’s innovation system; much more is involved and considerably more details are needed to fully appreciate the complexity and sophistication of the institutions engaged in innovation and their inter-relationships. Indeed, Canada’s innovation system has many dynamic participants who are involved in innovation in a variety of ways. For example, at the federal level, there are the research councils and laboratories, granting councils, centres of excellence, and the many departmental policy and program branches. Provincial governments, universities, hospital research units and other publicly funded research institutes are important elements of the system as well. Many major firms also perform R&D, particularly in the telecommunications, pharmaceutical, aerospace, energy, minerals and forest products sectors. As Canada’s Secretary of State for Science and Technology put it:

> *We have excellent universities and the federal granting councils are working to support our young researchers throughout the country. The Canada Foundation for Innovation gives them access to state of the art equipment. ... Through such programs as the Networks of Centres of Excellence, the councils also have a significant track record as enablers in building long term, productive partnerships between the university community and the private sector.*
> [The Honourable Gilbert Normand; 9, 9:10-9:15]

In Figure 3.4, the Committee tries to better capture this system as it relates to science and engineering disciplines (colour schemes of arrows remain the same as in Figures 3.2 and 3.3; system actors and organizations are identified by ovals, while specific innovation activities are represented by rectangles); there are obviously other innovation institutions and linkages outside of these disciplines. As an additional caveat, the system portrayed here is not comprehensive; some R&D performers, linkages and relationships, even within the above two disciplines, remain obscure or are not complete.

Figure 3.4
University Research in Science and Engineering



Source: Thomas Brzustowski, NSERC, Library of Parliament.

The university, while being funded largely by the provinces and secondarily by students, maintains research labs and directly and indirectly finances both basic and project research. Federal government contributions by the Canada Foundation for Innovation (CFI) for infrastructure and the Natural Sciences and Engineering Research Council (NSERC) to students and research teams for basic and project or applied research are also pivotal. The Committee refers to one witness' distinction between these two types of research activities:

> *Basic research is research carried on to make discoveries about nature,... about our position in nature. Project research is research done to solve problems, very often from industry but sometimes from government, that can't be solved with the knowledge we have today. So you have to create some knowledge to solve the problem. That's done very differently from basic research.*
> [Thomas Brzustowski; 4, 9:25]

Their motivations are sometimes different as well:

> *A great deal of research is done with no commercial end in mind whatsoever. In fact, I would say all basic research is done with no commercial end in mind ... Research in all areas of the environment is in that category, research that studies natural hazards and turns them into manageable risks for people, huge areas of research that have absolutely nothing in the way of commercial goals.*
> [Thomas Brzustowski; 4, 10:05]

Most codified knowledge comes from basic research, though project research is also a source:

> *The codified knowledge, the contribution to the Canadian 4%, comes largely out of basic research but not entirely. Some of it comes out of project research. Some of it flows back to the sponsoring companies in the form of solutions to their problems. These may be reports, these may be patents, or these may be software, but another stream ... is discoveries or inventions that have the potential to become innovations, the potential to be commercialized as new products on the market. It's not a large proportion. They enter first stages of commercialization in the universities, and they can go either as a licence to an existing firm or the basis of a start-up. Then the flows of innovation follow from that.*
> [Thomas Brzustowski; 4, 9:30]

Sometimes firms that do or buy R&D also share in the direct costs of specific project research at university labs; in this case, they provide the problems and the research unit provides the solutions, both of which are classified as knowledge. This codified knowledge (once recognized and demonstrated) could lead to intellectual property and the beginnings of the commercialization process, which is largely financed by private industry. At the same time, as important as knowing a firm's place in Canada's innovation system, one must also understand a firm's innovation processes.

We found that innovation depends both upon internally generated knowledge and knowledge that's acquired from outside the firm. Innovation processes fed from multiple sources, some internal to the firm, others external. Ideas for new and improved products and processes are generated in the course of market transactions with clients and suppliers, with related and unrelated firms, and with other external sources. Ideas for new market opportunities are seized and adapted to a firm's advantage by its management, research department, marketing, and engineering personnel in the firm. The innovation process then depends upon many actors. [John Baldwin; 13, 9:15]

These innovation processes across firms are not the same, however. Three classes or types of innovation systems used by industry were identified:

There are effectively three clusters of firm types that combine external links with internal capabilities. The first two groups rely on R&D. One builds networks with market partners; the other relies more on its extensive internal resources, and develops a capacity to ingest outside sources of knowledge by combining internal R&D expertise with spillovers of outside knowledge derived from research institutes. But there is a third cluster that's important in Canada, an alternative to the R&D-based model. It consists of those who focus on internal engineering capabilities and production expertise, and combined this with knowledge spillovers from universities. Universities appear to be an important part of the innovation process, in particular, when it comes to supporting applied research. In summary, the knowledge production process associated with innovation, relies heavily, but not exclusively, on R&D. [John Baldwin; 13, 9:15]

The outputs of these processes are usually the inputs of R&D firms and innovation start-ups, the ones who introduce new production processes, products or services to the marketplace. This relationship between R&D firms and innovation start-ups is often a tricky one, as it was explained as an organizational solution to some internal frictions within the firm, sometimes between production and sales divisions:

[T]he start-up enters the commercialization process … and might produce successful innovations in the market. But there's a new touch. … Quite often a company, maybe the same company that had been the partner, will buy this start-up and the mature technology. … They do this to get around their own internal frictions. This is in the area of destructive innovations versus sustaining innovations. … You can put yourself inside a company and understand how this happens. For instance, the vice-president of sales will say, "We can't develop this. You're going to have my salesmen go out there and say to the clients, to whom we've been saying, "This is the best thing in the world," that it's the second-best thing now because we have the best thing coming right behind it? We can't do that. We're already profitable in this line. We've made our investments. This is what the clients want. Why should we develop it?" So they put it into a spin-off. But once it's a product ready for the market, they can buy it and say, "We've just expanded our product line." [Thomas Brzustowski; 4, 9:40]

In any event, the innovations emanating from these firms make for new value-added economic activity. However, not all innovations make it off-the-shelf and not all innovations introduced to the market are successful. Failures are numerous.

[T]here are also failures to get to market and failures in the market. In addition, very often the company will simply not try to market a piece of intellectual property at all. It doesn't fit with its strategy. It might be too expensive, or it might be too far from its core line of business, so they create a start-up. Sometimes that happens not at the beginning of the commercialization process but partway through it. Sometimes a product is developed that is put on the shelf for strategic reasons: "Hey, we can't have this thing competing with our mainline product, which is making so much money. As long as the competition doesn't come up with something similar, we'll just keep this one on the shelf." [Thomas Brzustowski; 4, 9:40]

The successful innovations make for new value-added economic activity, which provides a return on investment to the innovative firm and generates taxes that flow back to both federal and provincial governments that may have even participated in the R&D impulse in the first place. Many highly skilled, high-paying jobs are created in the process. If governments are both wise and thorough in the research activities they conduct or help finance, and selectively and judiciously invest in "innovation infrastructure" so as to minimize systemic impediments, Canada's innovation system should operate effectively and efficiently, whereby the spillover effects of both basic and project research will payoff handsomely. The Committee, therefore, recommends:

3. That the Government of Canada adopt science and technology policies to strengthen the components of the country's innovation system and to improve the linkages between its components.

CHAPTER 4: THE INNOVATION POLICY FRAMEWORK

A Federal Government Role and Strategy

The public good (non-rivalrous) and non-exclusive (non-proprietary) nature of basic research, and some applied or project research, means that the innovator cannot appropriate all of the benefits associated with his or her invention. Without recourse to other institutional responses that would overcome the market's failure to adequately capture these spillover benefits as a reward to the innovator, governments were encouraged to consider actively stepping in and providing incentives and funding to restore a healthier level of R&D. Long-standing public policy was certainly simple given this rationale: we should be looking for the areas of research that have the largest spillover effects and fund the R&D work either directly through intramural government facilities or by provision of subsidy to the private R&D performer, or indirectly through the tax system. Although this seems relatively straightforward, it turns out that, in many cases, other institutional responses have in fact been open and available to the private sector.

> *Our work has shown that spillovers exist and that an awful lot of them, in the academic jargon, are internalized: firms operate networks that effectively internalize spillovers [and] allow them to extract the benefits for themselves. They find efficient ways to make markets work. But not all knowledge is protectable in that way. We have as a society looked at areas where we perceive that it is very difficult to internalize those spillovers.* [John Baldwin; 13, 9:50]

These findings suggest that policy based on the traditional linear view of innovation (basic research→applied research→patenting (sometimes)→technology development→ commercialization→production→marketing), which was heavily focused on basic research due to the much larger appropriability problem associated with this activity, was not as effective as one had previously thought and that other strategic pursuits might be more rewarding. Moreover, there were also practical lessons to be learned from past public policy initiatives:

> *[L]ooking at the history of policy and programs in support of science and technology — both in Canada and in other countries — it's extremely important not to push technological information and scientific information into the business community. What works best is to build up the capacity of business and the demand that business has for that information. I think there are too many programs that have failed, both in Canada and in other countries, that have been based on the premise that we simply provide business with information about new technological developments or simply build up a research capacity in this country and then expect business to pick that information up. Well, business has a lot of patents sitting in its files. ... What's important is to build up the receptor capability within businesses and*

> *their ability to not only develop new products but also invest in new enabling technologies*. [Jayson Myers; 13, 9:35]

Though perhaps this overstates the case when we consider the plight of small business:

> *When we then turn to look at other problems which have to do with information difficulties, information on foreign markets, information on new technologies, information that is obtained by collaborative exercises with other firms, small firms tell us those are major problems, large firms don't. Large firms are good ingesters of information. That's why they get large. They develop systems to obtain information.* [John Baldwin; 13, 10:00]

These and other discoveries convinced the S&T community to shift the emphasis of public policy away from the government being a performer of R&D, as well as attempting to pick between "winners and losers" when subsidizing private R&D projects, towards the government being a catalyst, facilitator and strategic investor of R&D.

> *I say we have to keep investing with our partners, universities and companies, but especially given that universities have new tools, new levers, it will be much easier for them to work with companies, and companies will be able to make better use of tax breaks if they do more work with universities. It enhances both, and both are crucial*. [The Honourable Gilbert Normand; 9, 9:45]

The S&T community had thus come to realize the futility in trying to pick the "technology winners," preferring instead that the winners emerge on the basis of their creative skills and business acumen within a strengthened innovation infrastructure. In this context, the public policy approach has been to invest in the innovation infrastructure, not individual performers, while attempting to bridge the talents and activities of different institutions engaged in the innovation process. Partnership initiatives and leverage funding thus became the operative direction of federal S&T strategy in the last half of the 1990s, as systemic failures, rather than market failures, became the principal hurdle to overcome.

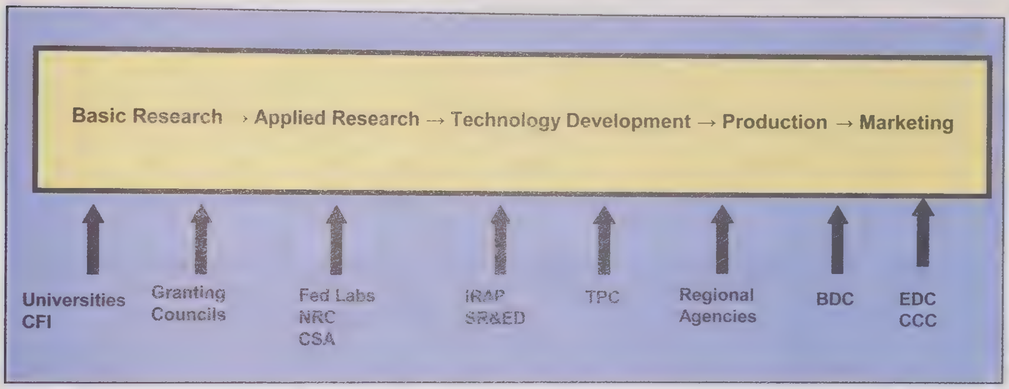
More formally, the federal government began to take a new strategic direction as set forth in its 1996 publication: *Science and Technology for the New Century — A Federal Strategy*. On the basis of this strategy, the government set out three goals for the federal investment in S&T:

- to ensure that Canada is among the best in the world in applying and commercializing S&T for sustainable job creation and economic growth;
- to ensure that Canada applies S&T to improve the quality of life for our citizens through the creation of fulfilling jobs and through the most effective social, environmental and health care programs in the world; and

- to create in Canada world centres of excellence in scientific discovery, to build a broad base of scientific enquiry, to foster Canadian participation in all major fields of science and technology, and to ensure that new knowledge can be acquired and disseminated widely from Canadian sources and from around the world.

This federal strategy provides direction to departments and agencies, and sets out the elements of a federal governance structure for their S&T activities. The strategy document was further accompanied by action plans for departments and agencies involved in S&T. While simplifying the role of each government agent or program, Figure 4.1 positions each along the innovation continuum according to the strategy's design.

Figure 4.1
Government Agents and Programs on the Innovation Continuum



Source: Technology Partnerships Canada, Industry Canada.

Finally, in the Throne Speech of 2001, the federal government committed itself to making Canada one of the top five most innovative countries in the world by 2010.

> *The "culture of innovation" is therefore a social project, and its success will, of course, depend on the collaboration of all stakeholders. Here again, we have every reason to be proud. Our researchers are among the most productive in the world, both in terms of the number of research-related publications and the level of international co-operation they have to their credit. These results prove that we are on the right path, but despite this, the Canadian government is fostering much more ambitious projects. We are determined to rank fifth in the world for investment in research and development by 2010. ... It is in this context that the Canadian government has promised to double its own expenditure on research and development by 2010.* [The Honourable Gilbert Normand; 9, 9:10]

The government intends to partner with provincial/territorial governments, businesses, educational institutions and individual Canadians to realize this goal. More specifically, the government has committed to:

- at least doubling federal expenditures on R&D;
- strengthening the research capacity of Canadian universities and government laboratories and institutions;
- accelerating Canada's ability to commercialize research discoveries;
- pursuing a global strategy for Canadian science and technology (S&T);
- strategically targeting new investments in research (e.g. in life sciences); and
- increasing support for the development of new technologies to assist Canadians with disabilities.

The Committee believes that the doubling of federal expenditures on R&D, should it leverage private sector spending by traditional amounts, is a tall order that would have Canada's GERD-to-GDP ratio approach 3% and would definitely put Canada in the top five R&D performers of the world, holding everything else constant. However, the facts are that everything else is very unlikely to be the same; other countries are also likely to significantly increase their government expenditures on R&D over the next decade to ensure their successful transition to a knowledge-based economy. Indeed, the Committee was made aware that:

> *Many other nations have also set ambitious R&D goals, with some countries such as Sweden and Finland already on target to reach 4% by 2010. As other countries are not standing still, … R&D investment in Canada will need to triple to place Canada near or among the top five OECD countries … by 2010.* [Robert Giroux, Association of Universities and Colleges of Canada; 23, 9:30]

While the Committee supports the federal government's R&D funding goal, it nevertheless has two misgivings with the above goals and fiscal commitments. First, the Committee believes that the objective of being one of the top five R&D performers is too narrowly focused. A broader approach that would encompass target goals of intermediate inputs to innovation, such as scientific publications and resident patent applications, should be included. Although the Committee understands that the government does not have direct control over these outputs of R&D, it is not without some influence. Because it is outcomes and not inputs that matter when it comes to innovation, the Committee recommends:

> **4. That the Government of Canada target the number of scientific publications (per 100,000 population) and resident patent applications (per 10,000 population), which are surrogate measures of scientific discoveries and technological innovation, respectively, produced and processed each year in Canada. Canada's relative performance should be benchmarked — and government policy should be assessed — on these terms against comparable countries of the world.**

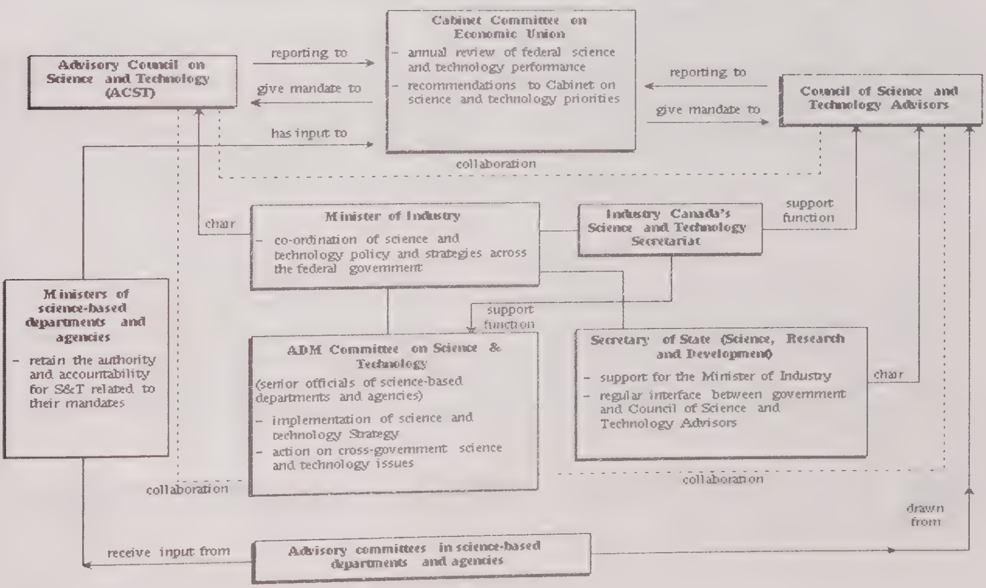
The Committee also believes that the government's fiscal commitments to implementing its strategy omit a couple of key ingredients. There is little or no new commitment to the improvement of technology development and diffusion. Although later chapters will discuss this issue in greater detail, the Committee recommends:

5. That the Government of Canada pledge its support and commitment to improved technology development and diffusion, particularly amongst Canadian small and medium-sized businesses.

Federal Governance: S&T Advice, Decision Making and Management

In the course of its S&T review, which began in 1994, the federal government decided to make a number of changes to the structure and processes of its decision-making. The Cabinet Committee on Economic Union (CCEU) was given the mandate to review the performance of federal S&T activities on an annual basis and to recommend priorities to Cabinet. To facilitate its review of S&T priorities, the CCEU is to receive advice from a new body, the Advisory Council on Science and Technology. The Council — which is composed of 12 eminent Canadians who represent academic, voluntary and industry stakeholders — replaces the National Advisory Board on Science and Technology that was disbanded at the beginning of the 1990s.

Exhibit 4.1
Federal Science and Technology Management Regime



Source: 1998 Annual Report of the Auditor General of Canada.

The improvement of top-level advisory and decision-making structures is not enough to ensure that the Canadian innovation system would yield best results, however. The government also recognized that an improvement in the management of its investment would also be required, which, first and foremost, necessitated more coordination of intramural S&T activities among federal agencies, as well as greater collaboration on major horizontal issues — those that cut across departmental and agency boundaries. This coordination function resides with the Minister of Industry and the Secretary of State (Science, Research and Development), who are supported by another new body, the Council of Science and Technology Advisors, comprising 22 advisors from outside government and chaired by the Secretary of State. Exhibit 4.1 provides a schematic of the decision-making structure and reporting lines concerning S&T activities in the federal government.

The present federal governance structure for S&T has a number of deficiencies related to overall coordination and the addition of the increasing number of councils has worsened the situation. This issue and a possible solution used in other countries were well presented by the Secretary of State (Science, Research and Development).

> *I would like to point out that, at present, the scientific sectors are very diversified. We have sectoral departments that conduct their own research such as, for example, Agriculture and Agri-Food, Fisheries and Oceans, Natural Resources, Environment and Industry, and it is very difficult to have what I would call an umbrella or some type of control over all these activities, so that there are some departments that do this job better than others, there are some that make less of an effort. I do not want to exaggerate the situation, but we know that this problem exists within the government apparatus.*
>
> *With the emergence of all of these granting councils, it is going to become increasingly difficult for sectoral ministers to oversee all of these activities. In the future, if we want to supervise, to some extent, the activities, not only of the granting councils, but also of the sectoral departments that do research, I think that we are going to have to obtain authorization from Cabinet or from the Prime Minister's Office. …*
>
> *At the present time we have a committee known as the Committee of Science and Technology Experts, whose meetings I attend, but what I want to point out is that several countries have set up systems. In the United States, Japan, Germany and Britain there is, at the level of the Prime Minister's Office, a scientific advisor and there is often a science minister who is not necessarily a sectoral minister but rather a minister whose mandate covers all such activities throughout the government in all areas.* [The Honourable Gilbert Normand; 9, 9:24]

Given the importance of maintaining a coordinated and cohesive federal role in S&T, the Committee recommends:

6. That the Government of Canada review its current governance structure for federal science and technology and transform the Secretary of State (Science, Research and Development) to a Minister of Science and Technology responsible for overall federal science and technology issues and programs.

The Committee is also of the view that there is merit in further exploring the creation of a Science and Technology Advisory Body, or modification of the current Advisory Council on Science and Technology that reports to the Prime Minister, that would report to Parliament. Indeed, the Committee intends to pursue this governance issue in greater detail in its next S&T report.

Federal Government S&T and R&D Activity Levels

In fiscal year 1999-2000, the federal government spent more than $6.3 billion on S&T (see Table 4.1). Intramural expenditures amounted to $3.3 billion, while extramural expenditures were at an all-time high of $3 billion; the growth of the latter being largely attributable to the CFI. Of this latter $3 billion, more than one third is allocated to Canadian business enterprises, $1.6 billion to Canadian higher education, $240 million to foreign S&T performers, $98 million to private non-profit institutions, and $33 million to other Canadian S&T performers, including provincial and municipal governments.

Table 4.1
Federal S&T Expenditures by Department/Agency in Fiscal Year 1999-2000

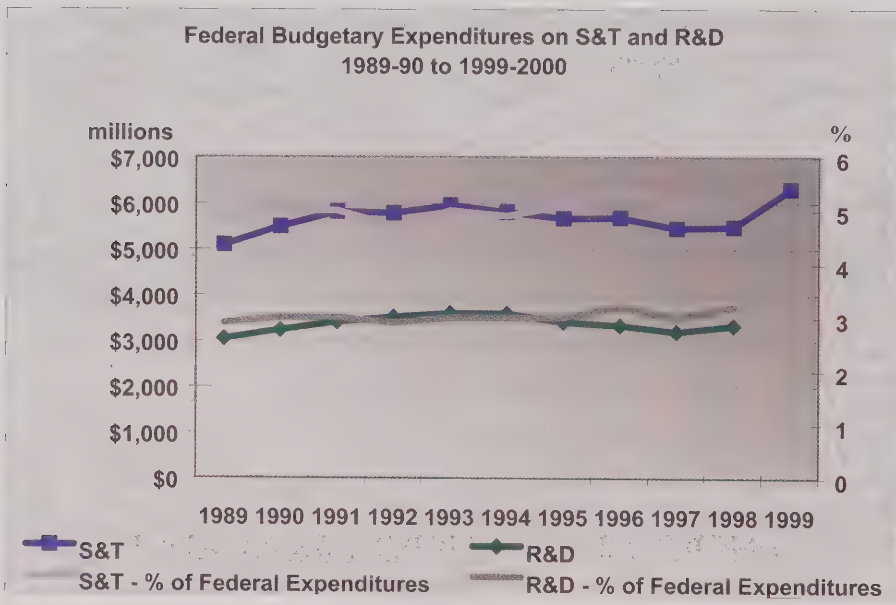
Institution	Amount ($ million)	Institution	Amount ($ million)
Federal Departments:		Federal Agencies:	
Agriculture and Agri-Food Canada	310	Atomic Energy of Canada Limited	120
Environment Canada	424	CIDA	347
Fisheries and Oceans Canada	205	Canada Space Agency	306
Health Canada	225	IDRC	81
Industry Canada	411	Canadian Institute for Health Research	309
National Defence Canada	553	National Research Council Canada	305
Natural Resources Canada	359	NSERC	540
Statistics Canada	419	SSHRC	121
Other*	668	Canada Foundation for Innovation	605
		Total	**6,308**

* Consolidates data of 39 federal departments and agencies, including Parks Canada, HRDC, DFAIT, the CFIA and Transport Canada.

Source: Statistics Canada. 1999. *Science Statistics*, Cat. No. 88-001-XIB, October 1999.

Figure 4.2 provides us with another perspective of federal expenditures on S&T and R&D. It indicates the federal government's commitment to its new innovation agenda over the last decade. Recalling from Chapter 2 that Canada's GERD-to-GDP fluctuated about 1.5% but managed an increase to somewhat more than 1.6% by the end of the decade, federal government gross expenditures on R&D has fluctuated about 3% of total government expenditures, also ending at an all-time high of 3.2%. The absolute dollar figures present a slightly different story, having peaked in 1993 at $3.59 billion before the federal government began its deficit reduction plan. While the trajectory of R&D expenditures was initially downward until its bottom was reached at $3.19 billion in 1997, the federal government's commitment to R&D is demonstrated by the fact that other expenditures were held more in check than those on R&D. The higher priority assigned to innovation is also confirmed in the S&T data. The absolute dollar figures spent by the federal government on S&T were down from its peak of $5.95 billion in 1993, bottoming out at $5.45 billion in 1997. At $6.3 billion in 1999, representing an average annual increase of 7.5% over the last two years of the decade, these expenditures are one of the fastest growing items in the federal government's budget.

Figure 4.2



Source: Statistics Canada and Finance Canada.

The data also confirm the new strategic approach taken by the federal government. Intramural R&D undertaken by the federal government represented 19% of total R&D performed in Canada, down from 29% in 1990. The business sector, followed by foreign sources, made the most inroads as an R&D performer, increasing their shares of total R&D performed from 41% to 49% and from 10% to 14%, respectively.

PART II: THE POLICY INSTRUMENTS

CHAPTER 5: STRATEGIC S&T INVESTMENT OPPORTUNITIES

Once the Committee had completed its examination of the innovation system it started looking at some of the major enablers for innovation in the twenty-first century. These major future-oriented S&T investments are important to Canada's long-term prosperity. Some have already received federal funding support while others are still being reviewed by the federal government. The Minister of Industry discussed the process and criteria that would be used in evaluating whether S&T initiatives should be funded.

> *I just would lay out a couple of principles. Certainly the most important principle is that we should be supporting excellence in our R&D. The merit principle should drive the examination of applications as they are brought forth, whether you're talking NRC or NSERC or the centres of excellence program, or, more recently, because it's had a higher profile, the CFI. All of the decisions on all of these programs are made at arm's length from me, from members of cabinet, from members of Parliament, from government generally. … [W]hen you have a block of funds … we could say to an expert panel — in the case of Genome Canada, a panel from outside the country — of international experts, "Give us your best advice, based on the applications before us, as to where these strategic investments across Canada should go." That's what we've done with respect to the space program, or … the neutron facility. These are the questions that would be determined by cabinet, specifically because they're large stand-alone projects. All the others are done independently.* [The Honourable Brian Tobin, Minister of Industry; 3, 16:00-16:05]

The Committee did not have the time to review all of the potential major S&T investment opportunities in Canada but it did have the chance to hear about a number of important initiatives related to: a proposed long-range plan for astronomy, biotechnology, genomics, nanotechnology, a proposal for a replacement neutron facility, and the light source synchrotron project. Some of these are better known than others but all are important to Canada's future. The Minister of Finance also recognizes the importance of these technologies:

> *It is all about timing. … I'm going to quote some words from Paul Martin talking about how Canada will build an innovative economy. He's talking about transformative technologies: "... this is where the true new economy is to be found ... in the transformative cascade of new technologies" — wave after wave after wave of new technologies. "This is producing a shift that is ... giving rise to whole new fields of industrial endeavour — information technology and biotechnology today, fuel cells, nanotechnology, and genomics tomorrow."* [Peter A. Hackett, National Research Council of Canada; 16, 9:52]

In reviewing these proposals the Committee grew concerned with the current review mechanism for major S&T investments, particularly those with an international component. This was especially evident with the proposed long-range plan for astronomy.

Astronomy — Long-Range Plan

The Committee was fortunate to receive an enlightening presentation on a major Canadian initiative/proposal with a distinctive international flavour. Canada's long-range plan (LRP) for astronomy and astrophysics was developed by an expert panel and reflects the consensus and support of the entire astronomical community. It builds on Canada's scientific and technical strengths to continue its international leadership in astronomy. The Committee learned that the LRP has also been publicly endorsed by all major stakeholders, including the presidents of all the government agencies involved in providing funding for astronomy in Canada: the National Research Council; the Canadian Space Agency; the Natural Sciences and Engineering Research Council; the presidents of all Canadian universities engaged in astronomical research; leaders of Canadian industry; and leaders in the field of public awareness in education and science. It has very broad support.

The Committee discovered that Canada has a prominent role on the world stage in the field of astronomy and astrophysics and that this field of research is poised to answer some fundamental questions.

> *To begin with, I'd like to give you a sense of the state of the discipline internationally and Canada's prominent role on the world stage. Advances in the power of technology over the past few decades, many pioneered by Canadians, have brought the field of astronomy to the brink of charting a complete history of time. Our most powerful telescopes, such as the Hubble space telescope, show us the universe as it was at half its present age. We are now poised to observe even further back in time and to answer fundamental questions that have engaged the curiosity of human beings throughout the ages. How did the highly structured universe we see around us come into being? When was the dawn of first light and the birth of stars and galaxies? How has the universe evolved, and what is its ultimate fate? When did the building blocks of life first occur in the history of the universe? Does life and possibly civilization exist elsewhere in the universe? Are we alone? How does humanity fit into this cosmic history?* [Russell A. Taylor, Coalition for Canadian Astronomy; 6, 9:25]

Witnesses informed the Committee that developing the new generation of telescopes requires international collaboration. Canada is an important player on the international front and, with respect to the science and technology community in Canada, astronomy leads all of the disciplines in international impact.

> *These and many other questions are driving the development of the next generation of ground-and-space-based telescopes. These telescopes will be so powerful and push current technology so hard that no individual country has the resources to*

develop them on their own. Astronomy is moving into an era of internationalization, where groups of developed countries work together and combine their resources to develop and build facilities that redefine the cutting edge. Canada is an important player in these international efforts. Most Canadians know that this country is a world leader in science and technology, but across all scientific disciplines Canada does about 5% of the world's research. The relative impact of a given discipline on the international stage is measured by the number of citations to published research — i.e., the uses of the published research by our international colleagues and other researchers. Within the science and technology community in Canada, astronomy leads all of the disciplines in international impact. … The impact per astronomer of Canadian astronomy makes this country the third most important player in this area in the world, behind the United States and the United Kingdom. We're ahead of all other major science and technology supporting countries. This is despite the fact that Canada has the lowest per capita funding level for astronomy among our G-7 partners, and in fact among the OECD. We're seven times less than the U.S. and five times less than the U.K. [Russell A. Taylor; 6, 9:26]

The Committee has previously passed a motion suggesting that the federal government support the $160 million funding cost for the LRP.

The House of Commons Standing Committee on Industry, Science and Technology fully supports the Long Range Plan (LRP) for Astronomy and Astrophysics. The LRP proposes an additional $16.4 million per year for 10 years totalling $164 million to be allocated to the National Research Council of Canada (NRC) and the Natural Sciences and Engineering Research Council of Canada (NSERC).

The Committee found the LRP to be an excellent proposal but felt that the review process involved in evaluating whether it should be funded needs to be more inclusive and more information on the proposal should be made available. The problem with the review/approval process noted with the LRP applies to all large S&T projects. The increasing importance of international collaboration in major scientific facilities and projects as well as the number of "big science" projects that need to be considered for future funding makes the need for a better review process a priority and the Committee recommends:

7. That the Government of Canada develop a definitive advisory process for large scientific projects, particularly those with an international component.

Biotechnology

Many Canadians frequently hear references to biotechnology in the press. The Minister of Industry noted the importance of biotechnology to Canada.

Biotechnology is another key enabling technology for the future. This vital scientific knowledge will provide new ways of dealing with environmental challenges, drive growth in existing and emerging industries, and lead to new medicines and the means to prevent disease. All of this is part of our vision of a smart country, an innovative and more integrated Canada for the future.
[The Honourable Brian Tobin; 3, 15:40]

This technology involves the application of science and engineering in the direct use of living organisms or parts or products of living organisms in their natural or modified forms. Although humanity has used biotechnology for centuries, it is only in the past 30 years that major discoveries have permitted its potential to be utilized.

It's only 30 years ago that our researchers discovered recombinant DNA. Now recombinant DNA is simply a vehicle that has led to the development of the entire biotechnology industry. … [T]he first product of biotechnology in Canada that I would suggest benefited the population was the development of human insulin. Human insulin was the first product, if you like, of genetic engineering. That was in 1982. Since that time, many biopharmaceutical treatments for AIDS and other diseases have been introduced, and many other projects are underway.
[Barry D. McLennan, Coalition for Biomedical and Health Research; 17, 10:43]

The long-term potential impact of the application of biotechnology is enormous but already many applications are being seen.

Let me come now to some benefits. Across town we have been working for 20 years in the development of vaccines based upon glycoproteins. These vaccines have just come to market and have just been used in the U.K. ... I could talk about the 1,000 lives that will be saved worldwide by 2015 using this vaccine. … Children are the last host of meningitis. So with a vaccine we will be able to remove this disease from the face of the earth, and that will be the real benefit of this biotechnology advance. There are seven other childhood diseases that are being targeted by this same technology. They're in the pipeline. They will come to market. …

Let me move on to benefits in the environment. … We have developed DNA chips to detect pathogens in water very cost effectively. Cryptosporidium parvum, etc., can now be detected with a $5 chip …

We've heard about Walkerton. Two days after Walkerton hit the news I had a brief on my desk from Dr. Malcolm Perry in our Institute for Biological Sciences. He said, "I have the answer; I've been working on this for 20 years." We now have a vaccine against E. coli 0157:H7 being developed with the VIDO organization at the University of Saskatchewan.

Osteoporosis. We've started a small company based upon synthetic PTH hormone. … This new technology not only repairs bone, it rebuilds bone. Of course, it will require many years of development and a large amount of investment to bring this technology to market, but we have started down that path

To talk further about benefits, on the economic side there is the incubation of small companies at the Biotechnology Research Institute in Montreal. There are currently, I think, about 20 small companies incubating. They have 260 employees. Some of these companies were attracted from the U.S., some from Europe.
[Peter A. Hackett; 17, 11:07]

Other benefits of biotechnology to Canada include stemming the "brain drain" and creating wealth for Canadians. It is one of Canada's fastest growth areas.

[B]iotechnology can contribute to stemming the brain drain, creating employment, and ultimately improving the personal and economic health of Canadians. ... Biotechnology cuts across many sectors. It should be noted that human and animal health dominate biotechnology activities in Canada, constituting 46% of industrial activity, about 87% of the research and development investment, and is the fastest growing job creation sector in our economy. [Barry D. McLennan; 17, 10:43]

The federal government has been very active in supporting biotechnology and the Committee actively encourages this support.

We're a small country, but we rank second in terms of the number of companies that use biotechnology. On a per capita basis, we're second in the world. Nonetheless, and even though our government—and we very much want to acknowledge the support of government. The federal government, already, has laid out some programs that are very important—the Canada Foundation for Innovation, the Canada Research Chairs Program, the Canadian Institutes of Health Research, and more recently Genome Canada. These are fantastic programs federally and provide opportunities in all the provinces for Canadian researchers to respond to the initiative. I compliment and want to thank the government right now for these very important strategic decisions. [Barry D. McLennan; 17, 10:43]

The Committee learned that biotechnology is converging with other technologies and that these mergers may well transform our economy.

We're on the verge of yet another revolution. Biology is transforming to a science based upon information. That's what genomics is all about. We're seeing the convergence of biotechnology with information technology. We're seeing the convergence of biotechnologies with materials technologies, and we're going to see the impact of biotechnology across all sectors of the economy. This new economy only comes from intensive research and development. R&D is the currency of the bioeconomy, and the bioeconomy is the future of biotechnology.
[Peter A. Hackett; 17, 11:00]

Developments in biotechnology are accelerating and witnesses asked whether Canadians are prepared to meet the challenge of the global biotechnology race.

Even though this biotechnology is developing at an accelerating speed, that presents us with a challenge, because as a nation and as a population we have to ask ourselves — and indeed that's the title of our brief — are Canadians prepared to meet the challenge of this global biotechnology race? Can we keep up? Can we put the resources in place to play in this game? [Barry D. McLennan; 17, 10:48]

The Committee's answers to these questions are in the affirmative.

Genomics

The recent completion of the preliminary draft of the genome[3] is one of the major scientific developments in the past few years. The Committee had the opportunity to learn about some recent developments in this area in Canada. The potential long-term benefits from the developments in genomics are staggering in terms of providing insight into such areas as hereditary diseases, susceptibility to environmental carcinogens, and enhancing human health. With these developments in genomics will come many opportunities for innovation.

[O]bviously the mapping of the human genome is an important event in the history of humanity from a science perspective and ought to benefit humanity and not just private individuals who would seek to take profit from it.
[The Honourable Brian Tobin; 3, 17:10]

The Canadian Biotechnology Strategy of Industry Canada incorporated Genome Canada as a not-for-profit organization in 1999. Genome Canada's objective is to support a national genomics research initiative. It comprises industry, government, Crown agencies, hospitals and universities. Genome Canada will coordinate research within, but not limited to, the areas of: (1) genomics and proteomics; (2) genotyping; (3) bioinformatics; (4) new technology development; and (5) ethical, legal and social implications. Genome Canada received $160 million in the 2000 Federal Budget and an additional grant of $140 million in February 2001. Funds from three sources — the Canada Foundation for Innovation, the private sector and provincial governments — will

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3 Genome: Every cell of an organism has a "genome," a set of chromosomes containing the hereditary genetic material that directs its development. The genetic material of chromosomes is deoxyribonucleic acid, more commonly known as DNA. Each of the paired strands of the DNA molecule is a linear array of subunits called nucleotides, or bases, of which there are four types: adenine, cytosine, thymine, and guanine. One way to appreciate the complexity of DNA is to visualize that the DNA in one single human cell would be approximately two metres long stretched out. The structure of DNA is the well-known double helix. About 140 base pairs of the DNA helix wind around a cluster of chromosome proteins to form a nucleosome, a structure similar to a bead on a string. Between the nucleosome beads is a string (linker region) of 20 to 100 DNA base pairs associated with another chromosome protein. This structure is flexible enough to permit the coiling and folding necessary to pack the DNA into the cell nucleus so as to make it readily available when it becomes genetically active. Genes are the discrete stretches of nucleotides that carry the information the cell requires to construct proteins. The human genome is composed of about 3 billion base pairs and contains 30,000 to 100,000 genes. The genes themselves take up only about 5 to 10 percent of the DNA. The function of the remaining DNA, which does not code for proteins, remains unknown although some may regulate whether or not proteins are made.

leverage the $300 million provided by the federal government and provide the total funding that Genome Canada projects will be required for its first five years of operation.

> *On February 28 I announced a further contribution of $140 million for Genome Canada. That brings total funding for that organization to some $300 million. That contribution is expected to leverage another $320 million in contributions from other partners by April 1, 2005.* [The Honourable Brian Tobin; 3, 15:45]

Although Canada has not spent much on genomics in the past, the Committee applauds the government's support of this very important research initiative that can benefit Canada and Canadians. The Committee was told that Genome Canada will face a number of challenges in the coming years which the Committee expects to be met.

> *[O]ur major challenge in the coming year, or perhaps over the next 18 months, is to move up from sixth to third place in terms of publications, because if we publish more while maintaining the same quality, Canada will definitely be a major player in specific areas. Our second challenge is to create international partnerships. This process has already begun. We currently have a list of 17 projects involving the best Canadian researchers. These projects are internationally competitive and it is now up to us to develop a partnership with foreign partners. Lastly, our final challenge is to make Genome Canada funding available to industry. We hope that over the coming year, an increasing number of Canadian biotechnology companies will be eligible for Genome Canada funding in co-operation with universities.* [Martin Godbout, Genome Canada; 16, 9:25]

Witnesses informed the Committee of the many excellent results from Genome Canada in its first year of operation.

> *As early as July 2000, the five Canadian centres and their respective boards had been set up. An inventory of over 275 projects had been submitted in the five genomics centres in Canada by September 2000. In November, the five centres submitted 73 letters of intent corresponding to 73 large-scale projects. These 73 projects were assessed by an international peer committee. On January 26, 2001, the five genomics centres each submitted a business plan. A total of 31 projects were presented in the five business plans representing maximum investments of over $600 million. … On March 22, 2001, a little less than a month ago, the board of Genome Canada selected 17 projects for the whole of Canada in five areas: health, the environment, forestry and fisheries and agriculture. These projects represented a total investment of $270 million, of which $135 million would be provided by Genome Canada and the remaining $135 million would come from the provinces.* [Martin Godbout; 16, 9:20]

The Committee was very pleased to see the federal and provincial governments actively supporting such a vitally important research initiative. It hopes to see more examples of this type of collaborative support in the area of S&T investments.

Nanotechnology

One of the key technologies of the future will be nanotechnology. At its fundamental level, this technology consists of making ultra-small machines to perform tasks. Nanotechnology has the potential to transform many aspects of society. It is very much in its infancy in terms of development and many of its applications are either yet undreamed of or are still in the realm of science fiction.

> *So what is nanotechnology? It's the fusion of life sciences and physical sciences, which one day will lead to faster computers, smarter robots, and even tiny probes that could engineer tasks within our body. Just to give some perspective, a nanometre is a billionth of a metre, or about four atoms placed side by side. So it's about making materials at the absolute fundamental limit.*
> [Peter A. Hackett; 16, 9:56]

One of the witnesses explained this technology in very practical terms.

> *We all are nanotechnology. Each of us operates because of biological machines that have been designed over millennia to be very, very efficient and very, very selective. Biology teaches us all about making molecular devices that carry out engineering type functions. And we need to bring this knowledge and this approach to the world of materials and the world of micro-electronics.*
> [Peter A. Hackett; 16, 9:56]

The Committee was concerned to hear that other nations are already investing heavily in this revolutionary technology while Canada is still only thinking about it.

> *The U.S., Europe, and Japan each spent $180 million in nanotechnology in 1997. In 2002, President Bush is requesting $485 million in the United States. Japan has just announced a $410 million program. In Osaka, 61 Japanese companies are forming a nanotechnology institute. In New York state IBM is co-funding a centre of excellence in nanotechnology this year. In Switzerland they have a well-integrated national effort, $24 million for advanced science and $55 million for commercialization. In Germany there are a number of large-scale efforts, including a $100 million program for early commercialization efforts.* [Peter A. Hackett; 16, 9:55]

> *On nanotechnology, we're working on it. We're currently seized with that question. I don't want to get ahead of the process, but we're very much interested.* [The Honourable Brian Tobin; 3, 17:12]

Clearly, government action is required.

Neutron Facility

Canada has one of 20 neutron facilities in the world. Neutron facilities generate neutrons that are used to conduct materials research. These facilities are a key S&T facility/tool that are used extensively by industry and academia. The current facility in

Chalk River is nearing the end of its useful life and a new facility needs to be built if we are to continue this work. There seems to be a fair amount of agreement among the research community that one component of Canada's twenty-first century scientific infrastructure should be this Canadian neutron facility at Chalk River.

> *Neutron beams are a probe that are used to investigate materials. This is the business of generating new knowledge about materials, things that people don't know already. Neutron beams give especially unique information about materials, and this unique information enables you to be competitive with how you make materials and how you implement them in the things we build in industry and in society. So this knowledge is used by three parts of Canada's knowledge infrastructure: universities for training and basic science; government laboratories, basic science directed at economic impact; and industry itself.* [John Root, National Research Council of Canada; 16, 10:10]

Today, thousands of researchers use neutron scattering in materials physics, chemistry, biology and engineering. This requires a specialized facility with highly trained staff and very expensive equipment.

> *It's a specialized resource. It requires a local team of experts to help non-expert users get the information they need out of the technique. As you saw, the team we have at Chalk River is very small. The members find opportunities in other countries very attractive; two of my six people have standing job offers in Australia. Two are very senior and will likely retire shortly. It will be difficult for me to bring in highly qualified people to replace them, so the essential personnel needed to make this technique available to Canadians will be gone. I feel it will happen soon. There's a threat. You need that expertise to help Canadians benefit from neutrons, and this situation means that Canadians will not have that access any more. Over the next few years I think you'll find that Canada's ability to exploit neutron information will dissipate across the nation. There will always be a few profs who go to international labs and benefit from the expertise there, but as you saw, there's an increasing demand on neutron sources worldwide. Canadians who aren't contributing may not be as welcome at these international labs as those who are players in the field. I think if you don't practise these advanced technologies and develop the knowledge on how to really exploit the information you get, you can't really benefit from access to foreign sources. I believe you'll be taking away from Canada one of the three pillars of advanced technology that support materials research.* [John Root; 16, 10:10]

There is a shortage of neutron facilities and other nations are replacing their neutron sources that are instrumental in some areas of advanced research.

> *While all around the world people are scrambling to replace their neutron sources, and here is the list of some of the projects that are going on right now. Small countries, non-nuclear countries, such as Australia, Korea, Taiwan, all recognize the neutron source is essential to support advanced-materials research and they're building them now. Larger projects, based on a different method for creating neutrons, are also underway, most notably in the United States. A $2-billion project called The Spalatian Neutron Source will be ready to produce neutrons in 2007.* [John Root; 16, 9:34]

The Committee learned that a Canadian proposal for a new facility called the Canadian Neutron Facility has been submitted to the federal government but that no decision has yet been made.

> *In Canada, we also have a proposal for a new neutron source. It has been called for over a decade by the neutron scattering community that Canada needs a new and improved source over what we already have at Chalk River. And this source is called the Canadian Neutron Facility. We're looking down from above a large laboratory. Here is the neutron source. It's very small, about the size of a bucket, and it shines neutrons out in many directions to feed a number of instrument stations. This project is going to cost around $466 million, escalated over six to eight years, but it will be a facility that has a life of 40 years and will support 20,000 research projects. So this is not a big science project that just answers one question; it answers thousands of questions and has an impact all across the economy of Canada*. [John Root; 16, 9:34]

> *The … (neutron facility) is one that is a priority for review, certainly, but I don't think government is ready at this stage to pronounce itself. We haven't completed the proper review and examination that's required, measuring this priority against all other priorities and seeing at the end of the day which meets the test for expenditure.* [The Honourable Brian Tobin; 3, 16:00]

The Committee thus waits.

Light Source Synchrotron Project

The Committee heard about another important scientific facility whose inception goes back to the late 1970s. On March 31, 1999, funding was announced for the Light Source Synchrotron Project, with the Canada Foundation for Innovation being the biggest contributor.

> *In Saskatoon, many of you will know, the Canadian light source synchrotron project at the University of Saskatchewan is providing an opportunity for basic research affecting a range of products, including newer drugs and vaccines, microscopic machines, implants, and more powerful computer microchips. This project is the largest initiative funded by the Canada Foundation for Innovation since its inception. Indeed, with all funding partners in, the capital cost of that project is about $170 million..* [The Honourable Brian Tobin; 3, 15:47]

Synchrotron radiation is the light produced when an extremely high-speed beam of charged particles (such as electrons) is bent in a magnetic field. This light covers the range of the electromagnetic radiation spectrum from infrared to gamma rays, and it is modern technology's best available source of X-rays. Canada is currently the only major industrial nation without its own dedicated synchrotron radiation facility in operation. This important project will provide Canadian researchers in many areas with an invaluable tool.

Virtually all of the scientific areas from biology, medicine, physics, chemistry, geology, agriculture, biotechnology, environmental sciences, mining, and archaeology can potentially benefit. … [B]iotechnology and pharmaceuticals and medicine can benefit from this, as well as advanced materials, information technologies and micro-systems, mining, natural resources, and the environment.
[Walter Davidson, National Research Council of Canada; 16, 9:40]

Although the Canadian Light Source Project expects to eventually get 25% of its revenue from industrial contracts, the project still lacks in approximately 18% of its operating funding needs. The Committee finds the approval of such important S&T facilities encouraging but questions how the project came to be funded by government while missing some of its required operating funding.

CHAPTER 6: "VALUE FOR MONEY" FROM FEDERAL S&T SUPPORT PROGRAMS

The federal government has identified and assigned itself a dual role of performer and facilitator of research. It fulfils these roles by performing research, using intramural capabilities and facilities, and funding extramural research and fostering partnerships among the various research-performing sectors. In terms of the latter role, the Government of Canada offers a number of direct mechanisms for providing support to R&D-active firms. From a policy perspective, the government funds private R&D because insufficient investment in the innovative activity will occur, owing to the fact that not all of the benefits of the invention accrue to the inventor and/or R&D performer. Also, there are advantages in having a government agency disseminate information and advice on the current state of technical knowledge, as well as what is in the realm of possibility, that would be too burdensome and time-consuming of an activity to acquire on one's own, even for the largest and well-financed firms. The government thus remunerates R&D performers and assists in the wider diffusion of products and technologies emanating from this and other R&D through its programs, as it is able to tax those who do derive the non-appropriable benefits of the invention or new products and technologies in order to finance the cost of the programs.

This Committee has no problem with the policy; it fully endorses the federal government providing financial support, business expertise and technical advice and assistance to R&D performers and users of R&D results. Instead, the Committee will deal with issues on how this policy is translated into programs, whereby consideration will be given to their design effectiveness and administrative accountability. This will enable us to determine the program's capacity to generate "value for money" on behalf of the Canadian taxpayer/citizen. Specifically, the Committee will address three R&D support programs: the Industrial Research Assistance Program (IRAP); Technology Partnerships Canada (TPC); and the Scientific Research and Experimental Development (SR&ED) tax incentive.

Industrial Research Assistance Program (IRAP)

Simply stated, IRAP helps small and medium-sized enterprises (SMEs) turn good ideas into commercially viable products and services. At a cost of about $135 million per year, IRAP attempts to increase the innovation capabilities of SMEs in a bid to become the national enabler of technological innovation for Canadian SMEs, which is consistent with its 50-year history. Administered by the National Research Council of Canada, the program's core competencies are in technology and innovation management, which can be divided into three categories: (1) technical advice; (2) network facilitator; and (3) shared funder of innovation projects. IRAP officials described their activities as follows:

The acquisition of tacit knowledge is encouraged by IRAP for SMEs. The undertaking of many experiments and transfers that would otherwise not be possible with the risks associated for small firms, encouraging the flow of information between users, between users and producers, and between sources of information. These mechanisms are extensively used. These are the networks that IRAP has been building. IRAP increases the firm's level of technical competence and the ability of the firm to create their own research and development results, as well as to be a receptor for the results generated by others. [Margot Montgomery, National Research Council of Canada; 20, 11:20]

At a glance, IRAP consists of 262 industrial technology advisors who are scientists and engineers located in over 90 communities across Canada, serving more than 12,000 SME clients annually. IRAP provided financial assistance to 4,343 innovation projects undertaken by 3,359 SMEs at a cost of $89 million in 1999-2000.

IRAP has been seriously scrutinized for effectiveness and efficiency over the years, with good marks often obtained. The Committee has no reason to quarrel with these assessments and will in fact refer to the results of the latest inquiry as shown in Exhibit 6.1. Dr. Lipsey's structural or institutional analysis better reflects the Committee's approach to R&D program evaluation.

Exhibit 6.1

Industrial Research Assistance Program IRAP-PARI Programme d'aide à la recherche industrielle

The Lipsey Study Concluded:

- IRAP encourages incremental innovation and the acquisition of tacit knowledge.
- IRAP encourages the capacity for, and the undertaking of, many technologies experiments and transfers.
- IRAP encourages flows of information between users and producers of many types and there is evidence that these mechanisms are extensively used.
- IRAP increases the firms' levels of technical competence and their ability to create their own R&D results, and also to use the results generated by others.
- IRAP has successfully created the technology information network and other related information mechanisms.

IRAP is often described as an exception to the general rule that government programs suffer from "being over-administered," as it is run in a "business-like manner." It certainly stands the test of its clients endorsing the program. This endorsement, however, does have its drawbacks, as has been pointed out by the Auditor General of Canada (AG). IRAP suffers from insufficient detail and due diligence in reporting results

and describing reasons why government funding was required. The Committee, therefore, recommends:

> **8. That the Government of Canada improve the reporting of the Industrial Research Assistance Program's project results without disturbing the "business-like manner" in which the program is delivered.**

Given the critical situation of reported low productivity of Canadian SMEs, the increasing market demand of innovative products and services, and the government's commitment to double its funding of R&D activities, the diffusion of technologies and dissemination of technical knowledge takes on increasing importance. Indeed, the Committee considers IRAP to be one of the most effective programs among the federal government's S&T policy instruments and, therefore, recommends:

> **9. That the Government of Canada immediately double its appropriations for an expansion of the Industrial Research Assistance Program.**

Technology Partnerships Canada (TPC)

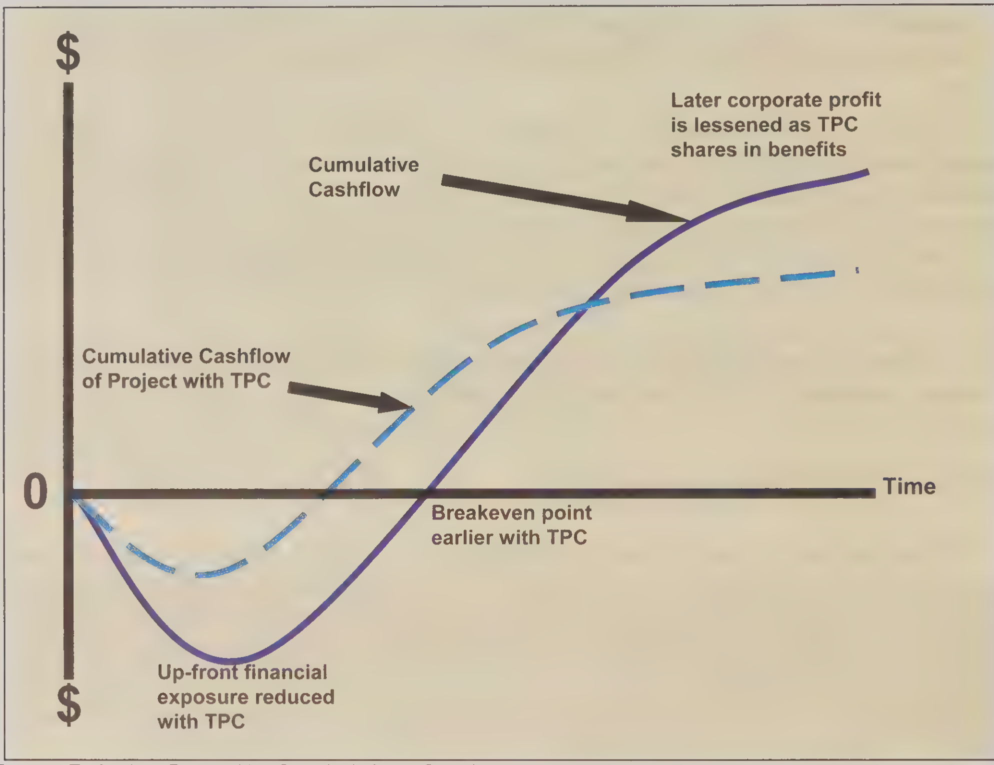
Organized as a Special Operating Agency, TPC is an investment fund (annual budget: $350 million) through which the federal government provides repayable contributions toward research conducted in Canadian companies in areas of strategic economic importance. By partnering with research companies and altering the time profile of a project's cash flow (see Exhibit 6.2), TPC encourages Canadian private-sector investment in maintaining and growing the technology base and capabilities of Canadian industry. TPC officials stress the fact that:

> *It's important to state that all of the investments that we make are repayable and … We expect to get a return on our investments.* [Jeffrey Parker, Technology Partnerships Canada; 20, 11:05]

In effect, TPC uses financial instruments (e.g., royalties, fixed repayments, warrants, etc.) to shorten the payback period, reduce the financial exposure and free up the R&D budget of a partnering research company. In terms of its economic impact:

> *Investments upstream basically help the company get to market faster and, therefore, it speeds up the process of expansion and development of the activity. Basically, we get paid back in terms of the downstream, when the product or when the technology becomes successful.* [Jeffrey Parker; 20, 11:05]

Exhibit 6.2
Financial Theory of Technology Partnerships Canada



Source: Technology Partnerships Canada, Industry Canada.

According to its current design, TPC's share in eligible project costs is not to exceed 33%. Projects must be in a qualifying technology sector: aerospace and defence industries, environmental and enabling technology (e.g. advanced manufacturing and processing technology, advanced materials, biotechnology and selected information technology). One additional constraint is currently being questioned:

> *[O]ne-third of the expenditures [of TPC] are targeted for enabling and environmental technologies and two-thirds of our expenditures are for aerospace and defence. … [W]e are in the process of taking a look at TPC's mandate, to make a decision as to whether or not it's advisable or appropriate to continue with that two-thirds, one-third split, to take a look as to whether or not TPC should broaden its focus in terms of the kinds of technologies it supports …* [Jeffrey Parker; 11:05-11:10]

Although the TPC program is still young, the Committee is aware that TPC has passed AG audits for due diligence in assessing "value for money" in its project funding, with only minor reporting problems. The Committee, however, believes the TPC program

can be made more effective at relatively no cost to the taxpayer by removing what appears to be a rather artificially crafted expenditure constraint. No one satisfactorily explained to the Committee the rationale behind the one-third, two-thirds split between aerospace/defence and advanced enabling technologies of total funds invested. It would seem far more logical to free up TPC funds to all qualifying industries and advanced technologies; this would allow it to optimize its investment portfolio. Furthermore, given the increasing market demand of innovative products and services and the government's commitment to double funding of R&D, the Committee recommends:

> **10. That the Government of Canada substantially increase its appropriations for an expansion of the Technology Partnerships Canada program and eliminate the one-third, two-thirds split between aerospace/defence and advanced enabling technologies of total funds invested from the mandate of Technology Partnerships Canada.**

Scientific Research & Experimental Development (SR&ED) Tax Credits

The federal government, through the Canada Customs and Revenue Agency (CCRA), operates the SR&ED tax incentive program. This program offers individuals, corporations and partnerships a tax deduction of up to 100% of qualified current scientific research and experimental development expenditures and eligible capital expenditures. The program allows eligible firms to offset tax owing, and individuals and SMEs may qualify for a cash refund of tax credits.

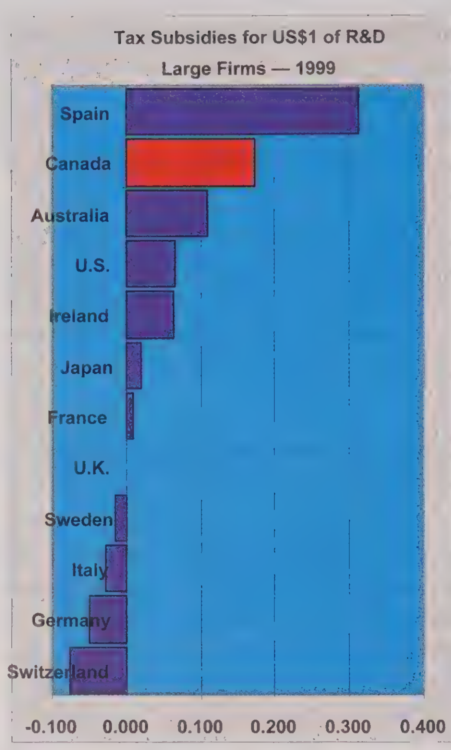
> *All R&D is allowed to be deductible in the year and, in addition, for large corporations we provide a 20% tax credit — for every $100 of R&D they do, they get $20 of tax reduction. For smaller companies, they receive a 35% credit calculated on their first $2 million of R&D. That amount is actually refundable.* [Paul Berg-Dick, Finance Canada; 20, 11:00]

This program has long been recognized as one of the most generous R&D tax credit programs anywhere (see Figure 6.1). Consequently, each year 11,000 Canadian firms, mostly SMEs, claim $1.4 billion in SR&ED tax credits from this program. These tax credits can also be augmented by a number of provincial tax credit programs. Finance Canada has determined the program's impact is extremely favourable: for every $1.00 of support the government puts in, it generated approximately $1.38 of additional R&D spending by firms; so it is extremely favourable.

The program is not without its distractions, however. The common complaint of the Canadian business sector, particularly SMEs, is the lack of timeliness in determining the eligibility of certain activities. In fact, Canada's AG has just reported on this problem:

In 2000 we reported the results of our audit of the government's administration of the tax incentives program for scientific research and experimental development. We asked whether management … had set clear rules and guidelines to help claimants and staff, had procedures in place to manage the risk of ineligible claims, and was resolving claims efficiently and effectively and treating taxpayers consistently. We found that there was significant room for improvement in each of these areas … [Richard Flageole, Auditor General of Canada; 20, 10:55]

Figure 6.1



Source: OECD, Science, Technology and Industry Outlook, 2000.

The Committee was told that the problem was so serious that some exacerbated SMEs just gave up on the program. While no one was able to quantify the loss in R&D that Canada suffers as a result, one witness reported what she claimed to be a startling statistic:

We did look at the numbers of IRAP clients who are receiving SR&ED tax credits, and we were dismayed that it was not a higher percentage. It's something around 50% or 48% … We have been working very proactively with the team from CCRA to try and align the business process of IRAP and the SR&ED claim process so that the SME who makes a proposal to IRAP for funding, and is funded, will automatically be compliant with the input to the SR&ED programs as sort of a paper work rationalization. [Margot Montgomery; 20, 12:00]

The Committee believes that SR&ED provides sufficient incentive and is indeed a generous contribution to private R&D; there is nothing on the benefits side that needs fixing. However, while we recognize that CCRA is working hard to correct administrative problems and that Canada's tax code is a complex one in terms of R&D definitions, the Committee believes the merging of eligibility of R&D expenditures between IRAP and SR&ED would provide a reasonable solution to some aspects of the administrative problem. The Committee, therefore, recommends:

11. That the Government of Canada expedite the work of the National Research Council and the Canada Customs and Revenue Agency to align their eligibility criteria of research and development expenditures and modify the relevant tax regulations that would see eligible research and development expenditures under the Industrial Research Assistance Program made de facto eligible under the Scientific Research and Experimental Development tax incentive program.

CHAPTER 7: FEDERAL RESEARCH AGENCIES

The government plays an important role in the science and technology field by undertaking R&D and related scientific activities utilizing its in-house capabilities.[4] As stated by the Government of Canada:

> *... the rationale for performing S&T within government needs to be based on a demonstration that the work is relevant to specific needs of government, that it can be done more effectively and/or efficiently in government facilities than it could be done elsewhere, and that, if the government did not do it, it would either not get done, or else would be done in a manner or a time frame that is not suitable for responding to the needs of the government.*[5]

Furthermore, the federal government needs to have some degree of in-house scientific and/or technological capacity in order to effectively exercise the option of outsourcing some types of research projects (i.e. both for competency and competitiveness reasons).

The Committee was unable, in the time available, to pursue or assess the performance and capacities of federal departmental R&D labs, but intends to thoroughly investigate this aspect of the country's S&T capacity in the fall. For now, the Committee chose to focus on selective and key federal R&D agencies: the National Research Council of Canada (NRC); the Networks of Centres of Excellence (NCE); and the Canadian Space Agency (CSA). The overview provided here, however, does not focus on their effectiveness in meeting their mandates (in most cases, the lack of competition in the field of strategic or long-term research means that there is no consistent way of comparing or benchmarking results) or the accountability of their administrations (this, we leave to the Auditor General of Canada to report on). In its place, the Committee pursued the breadth of the current and proposed mandates of the agencies and the resources available to attain them in order to gauge their role within the national innovation system and their potential contributions to a knowledge-based economy.

National Research Council of Canada (NRC)

As Canada's foremost R&D agency, the NRC's vision is to be a leader in the development of the knowledge-based economy through science and technology. The Council operates a network of research laboratories that can collectively boast of a wealth of knowledge, expertise and capability of substantial value to Canadian industry. In fact,

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4 Related scientific activities encompass actions to reinforce the findings of R&D by disseminating and applying S&T knowledge, which would include data collection, testing, and scientific and technical information services.

5 Council of Science and Technology Advisors, *Building Excellence in Science and Technology (BEST): The Federal Roles in Performing Science and Technology*, 1999, p. 12.

the NRC is involved across the innovation continuum from basic research performed mainly in the universities through to developmental research, conducted mostly by private firms.

The primary mission of NRC laboratories is to undertake research that specifically supports the mandates of the agency, i.e. a number of strategic objectives. However, in all cases, there is an explicit aim to transfer technologies developed in-house to Canadian companies with the capacity to develop commercial applications that benefit the Canadian economy as a whole. For this reason, many of the 16 NRC laboratories across the country undertake collaborative research with Canadian companies. Canadian firms are thus able to have access to state-of-the-art facilities that would otherwise be unavailable to them. An NRC official explained its role as follows:

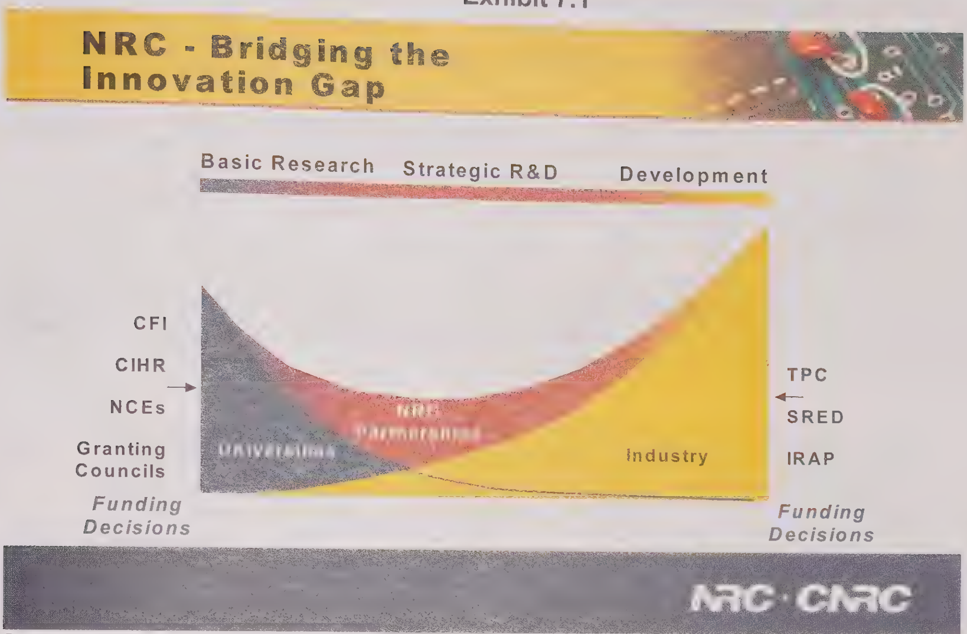
> *NRC is a departmental corporation … with strong links with partners, clients in industry, both large and small firms, in university, in research hospitals and to the international scientific community as well. Our vision is national, but it's delivered in large measure by building upon our regional strength and upon R&D opportunities. … NRC plays a unique leadership role … [w]e integrate R&D performers through novel forms of partnership, including collaborative projects, through innovation networks.* [Lucie Lapointe, National Research Council of Canada; 20, 9:05-9:10]

On this last point, the NRC claims to have leveraged three times its financial contribution from its partners in their mutual research projects. The end result of this collaboration has been many small incremental investments in innovation.

The business strategy that has generated these results is one where the NRC acts as a bridge between the activities and players at either end of the innovation continuum, which incorporates pure science, mostly conducted by universities, at the one end, and pure application or development of technology, mostly conducted by industry, at the other end (see Exhibit 7.1). According to NRC officials, it is in the middle of this continuum where little activity had been taking place and the consequences of such an "innovation gap" is insufficient capacity available to translate ideas into products for the marketplace, a problem that has been singled out as particularly acute in Canada.

The NRC believes that it has all of the tools to be able to contribute to the solution of this innovation gap. In the past decade, the Council has re-engineered itself and is now positioned in the middle of that continuum. The NRC does carry out basic research and development, but its principal activity today is bridging the gap, which involves working in partnership with other players — large and small enterprises, universities, and other government labs — to not only develop technology but also to translate that technology into products for the marketplace.

Exhibit 7.1



Source: National Research Council of Canada.

The Committee questioned whether the NRC has sufficient capital to fully implement its mandate and mission, and considered the value of it being made eligible to receive funding from the CFI. The presidents of the three granting councils gave their unconditional approval to this suggestion, arguing that the NRC requires a lot more funds than it presently receives to properly carry out its mandate and that the source of these funds is really immaterial. The Committee concurs with these views and is of the opinion that such a proposal has merit and should, therefore, be considered in more detail when the Committee undertakes its major review of the CFI this fall.

The Committee further recognizes that innovation and industrial growth are often a local phenomenon, driven in communities by clusters of innovative, R&D-active firms and local entrepreneurs. Community-based technology clusters — in which innovative, technology-intensive firms working in related fields co-locate, interact, compete and grow in a supportive environment — have proven to be a successful formula for promoting research that has led to substantial economic growth and increased international competitiveness. In this vein, the Committee equally realizes that many of the economic clusters in Canada have developed around existing federal laboratories and research institutions, most notably those of the NRC, including:

- information technologies and telecommunications in Ottawa;
- agricultural biotechnologies in Saskatoon; and

- pharmaceutical biotechnologies in Montreal.

The NRC explained a little about its cluster strategy:

> *Our strategy is to connect NRC's core research strength—our knowledge and partnership network—with commercial development and product-oriented achievement of industry That to us provides a winning innovation formula. For a small, incremental investment, we have the opportunity to make a considerable impact.* [Lucie Lapointe; 20, 9:15]

However, when pressed to explain the NRC's reasoning behind a proposal to establish an automotive technology based cluster in London, Ontario, when one is already located in Windsor, Ontario, we were told:

> *[W]e currently have research institute in London and we are not proposing an additional research institute or any such thing. We have an integrated manufacturing technology institute located in London, Ontario, and I should add that significant investments from those companies … have been made in the institute…* [Lucie Lapointe; 20, 10:35]

> *AUTO 21 has its administrative centre in Windsor and has obviously a lot a research there, it also involves communities from across the country. … I can assure you … that should a new research centre establish itself somewhere it will be linked to AUTO 21.* [Jean-Claude Gavrel, Network of Centres of Excellence; 20, 10:30]

The NRC is also working with the federal regional development agencies — the Atlantic Canada Opportunities Agency, Canada Economic Development for Quebec Regions, and Western Economic Diversification Canada — which have identified innovation as priority themes for their activities. The new focus of the NRC has thus produced numerous local success stories; quantitatively, however, the Committee was told that:

> *Over the past five years, NRC's partnerships with industry have doubled. We have nearly tripled those with public organizations and those with the universities have grown five-fold. The revenue from R&D service ... and … licensing has reached $100 million a year. We have incubated 83 firms in our industry partnership facilities and more than 1,600 new collaborative agreements have been signed by industry with universities and with international organizations.* [Lucie Lapointe; 20, 9:10]

The Committee supports the NRC's cluster strategy but has concerns on how this strategy is being applied. More precisely, the Committee would like to know more about the current distribution of technology clusters across the country and on just how cluster locations are chosen. The Committee will pursue these concerns in the fall but, in the interim, recommends:

12. That the Government of Canada provide financial support to the National Research Council of Canada to implement an expanded innovation cluster strategy.

Networks of Centres of Excellence (NCE)

The Networks of Centres of Excellence (NCE) program is administered jointly by the three federal granting councils and Industry Canada. In a somewhat similar vein as the cluster strategy of the NRC, the program provides a mechanism for bringing together researchers from universities, the private sector and government — often across a number of disciplines — to address research issues of common concern that have economic potential. As it was put to the Committee:

> *The program was created in 1989. … The idea is to foster synergies between what we call the creators of the knowledge and the users of that knowledge. That's where the link of the private sector comes in as an extremely powerful element to it. We focus on areas of critical importance and large problems that will obviously have benefits for Canadians.* [Jean-Claude Gavrel, 20, 9:45]

This type of cluster or partnership was described as a virtual organization with the following typical structure:

> *An NCE is managed by a board of directors, a board that has representation from the sector but not from the people who actually receive the money … The responsibility of that board is to manage … the funds, to determine where the research should be carried out and to basically ensure the accountability of those research dollars. NCE can be broken down usually into about four to six research themes, for a total of maybe 15-20 projects.* [Jean-Claude Gavrel; 20, 9:50]

Currently, there are 22 NCE linking more than 900 Canadian organizations that employ more than 5,000 people. NCE have investigated questions in fields as diverse as space research, respiratory health, stem cells, protein engineering, telecommunications, microelectronics, photonics, aquaculture and sustainable forestry. At a cost of $77 million per annum to the federal taxpayer, the program has leveraged private-sector investment in research to a total of $160 million. The NCE program has produced concrete results: 66 patents filed, 31 patents awarded, 71 licences granted and 78 spin-off private ventures formed.

The Committee believes that the NCE program constitutes a vital component of Canada's innovation system. However, before making a recommendation on the appropriate level of financial support the NCE should receive from the federal government, the Committee would like to review the NCE's funding requirement in detail.

Canadian Space Agency (CSA)

The Canadian Space Agency (CSA), formed in 1989, has pursued a mission committed to leading the development and application of space knowledge for the benefit of Canadians and humanity. The CSA has five strategic areas of operation: earth and the environment; satellite communications; space technology; human presence in space; and space science. On the occasion of its tenth birthday, the government for the first time made a long-term commitment to space development:

> *[F]or the first time the budget in 1999 provided for the Canadian Space Agency a stable ongoing level of funding of about $300 million a year starting in 2002 or 2003. This is a major shift on how the government has funded the Canadian space program. Prior to this … our funding was based solely on specifically approved projects. When the project is completed, the funding for the agency would decline. Now like any other government organization, we have the ability to plan on a stable financial basis.* [Mac Evans, Canadian Space Agency; 20, 9:25]

The Committee, like most Canadians, is well aware of Canada's accomplishments in space. The Canadian astronaut program and the development of space robotics, such as the Canadarm, are two very large contributions for which we can be justly proud. However, the CSA has other notable accomplishments that are not as widely known:

> *Our space technology program is in fact the launch pad for innovation in the whole space program. … Through this program we are able to contract R&D to industry. We are able to develop activities which will allow those industries to take their new technologies and fly them in space and get them space qualified so that they can have an important element of their product commercialization activities looked after. … This program carried out more than 200 projects in the last year. It resulted in 48 patents, 59 licenses and 60 papers having been published. This is the program that works mostly with SMEs across the country to assist them in their research activities. And the focus of this program is in the areas of remote sensing, satellite communications and space robotics.* [Mac Evans; 20, 9:35]

The Committee clearly endorses the government's strategic investment in the CSA and its activities. The frontiers of space research will likely hold great promise for us all in the future. The Committee, therefore, recommends:

13. That the Government of Canada increase its financial support of the Canadian Space Agency to enable Canada to play a more significant role in national and international space science projects as part of its innovation agenda.

CHAPTER 8: THE GRANTING COUNCILS AND THE CANADA FOUNDATION FOR INNOVATION

Government financial support for university research and research training is predominantly made available through the three federal granting councils: the Natural Sciences and Engineering Research Council of Canada (NSERC), the Social Sciences and Humanities Research Council of Canada (SSHRC), and the Canadian Institute for Health Research (CIHR). These councils collectively provide peer-reviewed funding for more than 17,000 researchers across the country in disciplines spanning from molecular biology to cancer research, neurotrauma research, particle physics, oceanography, behavioural psychology, economics and literacy. These investments in pure and applied research are made, first and foremost, to extend the boundaries of knowledge and, secondarily, to turn good ideas with prospects of commercial application into products for the marketplace. Indeed, researchers are increasingly finding new applications for their research results and, in some cases, they are also commercializing and disseminating these results for others to use. These investments also support the training of Canada's brightest young minds by both imparting important skills and developing expertise that can be applied across all sectors of the economy.

In 1997, the Government Canada widened its set of policy instruments of support for R&D in Canada beyond the three granting councils with the establishment of the Canada Foundation for Innovation (CFI). The CFI is an independent corporation whose mandate is to strengthen the research infrastructure at Canadian universities, colleges, research hospitals and other not-for-profit institutions to enable them to carry out world-class research and technology development. By investing together with other funding partners from the public, private and voluntary sectors, the CFI helps to ensure that Canadian researchers will have access to state-of-the-art equipment and facilities. The CFI programs are designed to: build Canada's capacity for innovation; attract and retain highly skilled research personnel in Canada; strengthen research training of young Canadians for the knowledge economy; promote networking, collaboration and multidisciplinary approaches to problem-solving among researchers; and ensure the optimal use of research infrastructure within and among Canadian institutions.[6]

Together, these policy statements and actions demonstrate the government's commitment to its innovation agenda and its favouritism towards supporting and facilitating R&D activities of the research community at large. One witness, who is closely engaged in this agenda, reinforced this view:

> *In October $500 million was announced to provide a contribution to the operating costs of CFI-supported facilities and to expand international collaboration. These increases, the extension of our mandate, the creation of the Canada research chairs*

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6 Canada Foundation for Innovation, www.innovation.ca.

program, the doubling of the CIHR budget, increases to the other granting councils, as well as the establishment and additional funding of Genome Canada, represent an unprecedented level of support by the Government of Canada. It's sending a powerful signal to Canada's research institutions and shows the central role they are playing to ensure Canada's innovation capacity on the world scene. [David Strangway, Canada Foundation for Innovation; 10, 9:10]

Unfortunately, the Committee was unable, in the time available, to assess the performance or effectiveness of these federal agencies in meeting their mandates. Instead, the Committee chose to pursue the breadth of the current mandates of the peer-review councils and the CFI, along with the resources available to attain them, in order to gauge their role within the national innovation system and their potential contributions to a knowledge-based economy.

The Peer-Review Approach to Funding Research

When it comes to public goods such as research work, particularly basic research, the private marketplace will undervalue and, therefore, underproduce this socially beneficial work (in an optimizing sense). This can be taken as a given when all the benefits of the research cannot be appropriated by the researcher. However, the opposite side of this coin is that if we leave it strictly to government to underwrite these research projects, the subsidy will attract all researchers, even those with privately rewarding projects needing absolutely no public funding whatsoever, not to mention a litany of researchers with unworthy projects. Without some way of limiting government's commitment to fund research proposals, we risk overvaluing and, therefore, overproducing research work (again, in an optimizing sense). Obviously, a balance must be struck and some sort of rationing device must be adopted to avoid a situation where demand outstrips supply and we are engaged in research for research sake.

The rationing device used by all three granting councils and the CFI is the peer-review process. Peer review is the assessment of research proposals or research contributions by impartial experts in a specific field. Applicants typically submit in their grant application: the proposed research; career achievements of the individual or firm; contributions to the training of highly qualified personnel; an itemized budget, etc. Grant selection committees are peer-review committees drawing highly qualified people from Canadian universities, industry, government laboratories and foreign institutions. Each of these peers provides a unique perspective and valuable contributions to the decision process. In the end, the peers decide who may get council funding for his research work and, by implication, who may not get government funding. Appeal mechanisms are usually put in place to assure mistakes or unfair treatment does not occur.

Besides the benefits of being intimately knowledgeable of the disciplines and the industry for which funding is requested, an advantage of the peer-review process is that the panel of experts can remain flexible in choosing between alternative strategies such as opting in favour of providing relatively large grants to a small and very selective group

of researchers requesting funds or providing relatively smaller grants to a large number or broad range of researchers. Only experts in the field can know what works best in each discipline and what is more likely to produce innovation and advance knowledge. Moreover, often there is some trade-off between "excellence" and "innovation" in funding research projects and only a panel of experts could plausibly manage such a tradeoff in an efficient manner. Consider one such decision made by NSERC. As with all three granting councils, the demand for NSERC funds far exceeds supply. NSERC responded this year in the following way:

> *The … last competition held in February, a competition of about 3,000 applications, … we had no budget increased to accommodate these people [but] we've decided to fund 567 of them at 39% of the funding requested. So the fraction of applicants funded is large. The percentage of the funding requested is small.* [Thomas Brzustowski; 23, 10:40]

Similar types of tradeoffs were made by SSHRC and CIHR, though the size and percentage of applicants differs substantially.

In the upcoming years, it is well known that there is going to be considerable turnover of professors at Canadian universities. Many will retire and they will have to be replaced. The consequent loss in expertise and research experience will be tremendous, but their younger replacements will be of a different genre, with far greater appetites for research. The change in composition of the professorship at Canadian universities suggests that demand for research funds at all three granting councils will skyrocket.

> *Universities are going through changes. Many professors are retiring and a lot of new professors are coming in. We are facing an incredible growth. In all, 762 new professors have applied in a competition addressed to less then 3,000 people. This represents a 25% growth. The first priority for us is granting research funds for these newcomers in small and large universities.* [Thomas Brzustowski; 4, 9:50]

If Canada is not to lose its best and brightest, it cannot afford to hold the line on research funding knowing full well that demand will grow at unprecedented rates. With diminishing prospects for research funding and building a good team, while being forced to endure working with aging equipment, researchers will turn off and move elsewhere.

Clearly, if the government is to deliver on its agenda to double the amount of research in Canada, it will have to rely increasingly on university researchers and, by implication, the three granting councils as the funding vehicle of choice. The Committee also strongly supports the government's strategy of directly funding private researchers and their collaborative teams. However, the Committee has great concerns on how the granting councils carry out their mandates and on the selection criteria they use for funding projects.

Another pressing issue the Committee found troubling was the relatively weak research capacity of small universities, particularly those in Atlantic and Western Canada. This weakness or disparity in regional research capacity shows up in the success rates of applicants to the granting councils. The Committee understands that it is not because their faculties do not have the potential to achieve research excellence, but because of a number of barriers such as: heavy teaching workloads; inadequate laboratory space, workshops, technicians and basic equipment; and, probably most importantly, low levels of value-added industrial activity. Clearly, this structural difference in regional economies and provincial funding of universities cannot be fixed overnight.

Together, these concerns warrant further investigation by the Committee. Indeed, the federal government's commitment to double Canada's R&D expenditures by 2010 is opportune in that before such funding increases are delivered by the government, the Committee's review of the mandates, processes and decision-making criteria of the granting councils (scheduled for this fall) is essential to ensure good management of these scarce resources.

Natural Sciences and Engineering Research Council of Canada (NSERC)

NSERC supports research in universities and colleges, research training of scientists and engineers, and research-based innovation. The Council promotes excellence in intellectual creativity in both the generation and use of new knowledge, and it works to provide the largest possible number of Canadians with leading-edge knowledge and skills. NSERC fulfils this mission by awarding scholarships and research grants through peer-reviewed competition and by building partnerships among universities, colleges, governments and the private sector. NSERC goes about this funding in the following way:

> *We support people — undergraduate, graduate and post-doctoral students—in two ways ... One is through scholarships that they win in their own name and another is out of the research grants of the principal investigators. They can be paid either way and in fact roughly equal numbers are supported in each of these two ways. But we also support dedicated technicians and research associates. Then [there are the] operating costs. These are the direct costs, these are the costs of doing research that the principle investigator faces. This is what we give our research grants for in many cases in addition to supporting people.* [Thomas Brzustowski; 23, 10:40]

As with all three granting councils, the demand for NSERC funds far exceeds supply. In fact, NSERC reports that on the industrial side of its mandate, it has had to suspend some competitions:

> *On the industrial side ... a conscious decision [was made by] NSERC ... that because the research grants to professors are the very foundation of the pyramid everything is built on, that was priority. So we will not cut programs but we will suspend competitions in order to make up for that overspending in one of our programs.* [Thomas Brzustowski; 23, 10:40]

Looking at some of NSERC's most recent accomplishments, the Committee notes that, in 1999-2000, NSERC supported over 8,700 university professors, 15,000 university students and post-doctoral fellows, and another 3,100 university technicians. This bodes well for both scientific discoveries and building industry's so-called "receptor capacity." Furthermore, the number of firms that have participated with NSERC programs rose from 50 in 1983 to about 500 in 1999. Today, for every dollar NSERC invests in a project, an additional dollar and seventy cents is contributed by industry and others. The Committee is impressed with these results and believes that NSERC programs, which cost taxpayers just short of $600 million in 2000-2001, represent money well spent.

Over the next several years, the federal investment of $1.9 billion for the Canada Foundation for Innovation (CFI) will translate into over $5.5 billion in investment in much-needed infrastructure. However, while the CFI will strengthen the capacity of Canada's universities to conduct research, it will also create challenges for all sectors. NSERC, which funds the direct costs of research, anticipates a large increase in the demand for funding to operate the new facilities and laboratories. NSERC estimates an increase in demand for funding by at least $135 million per year. Moreover, the cost of performing leading-edge, world-class research is rising — due to a weak Canadian dollar relative to the U.S. dollar, the source country of most scientific equipment imports, and to new and more expensive research methods — which will cause greater dependence on NSERC funding.

Social Sciences and Humanities Research Council of Canada (SSHRC)

SSHRC is the national agency responsible for supporting university-based research in the social sciences and humanities. SSHRC funds basic research — that is, targeted research on issues of national importance — the training of highly qualified personnel and the broad dissemination of knowledge for the benefit of Canadians. Its programs and strategies promote research excellence, innovation, productivity and partnerships with users of research in public, private and community sectors.

The demand for SSHRC funding also significantly outstrips its ability to supply, probably more so than the other granting councils. SSHRC reports its most innovative programs can only fund between 10% and 20% of meritorious proposals. For example, the Community University Research Alliances program — which supports the creation of dynamic research partnerships between universities and their local communities — was able to support only 37 projects from among 298 submissions.

The president of SSHRC felt there was an inequity between his granting council and the other two councils. He mentioned that students and faculties in the social sciences and humanities constitute the major portion of the so-called "human capital" at Canadian universities, yet receive a significantly lower share of the federal S&T funding budget. This inequity is even more skewed when one factors in the fact that SSHRC allocates proportionately more funds to small and medium-sized businesses in Canada,

where the “innovation gap” is said to exist. Relatively less funding has forced the Council to provide very small grants.

> *One of the striking conclusions is what’s on that graph there that in the social sciences and humanities, the proportion of funds going to students is very low because the grants are so small. The average size of a grant is $17,000 a year.* [Marc Renaud, Social Sciences and Humanities Research Council of Canada; 23, 11:40]

The Committee is satisfied that the recent commitment by the government to double SSHRC’s appropriations to $400 million provides a good start at redressing the apparent inequity among the granting councils.

Canadian Institute for Health Research (CIHR)

The CIHR is the federal agency with primary responsibility for funding, promoting and sustaining basic, applied and clinical research in the health sector. Its mandate is much broader than its forerunner organization, the Medical Research Council of Canada (MRC), which now spans everything from basic or fundamental laboratory research right up to social sciences as it pertains to health, health services and research. More specifically, its objective is to “excel, according to internationally accepted standards of scientific excellence, in the creation of new knowledge and its translation into improved health for Canadians, more effective health services and products and a strengthened Canadian health care system.”

Over the past few years, the former MRC and a broad range of partners and stakeholders in health research came together to promote a common cause: a new vision for health research in Canada. This vision is predicated on the belief that an increased investment in extramural health research is an indispensable step in improving the health of Canadians and on recent and forthcoming new advances:

> *This has been called the “century of health research,” the “biocentury,” the “century of genomics” — you name it. I think it’s a reflection of the great excitement that has been generated by the sequencing of the human genome. We now are in a position, of course, to understand the molecular basis of human biology, of health and disease. The implications and ramifications of that new information is going to be all pervasive. It’s going to pervade not just research in universities and hospitals, but it’s going to pervade the health care system and it’s going to pervade the industry in terms of the explosive growth of the biotech sector in Canada and around the world.* [Allan Bernstein, Canadian Institute for Health Research; 23, 10:55]

A new operational framework that provides the instruments for the CIHR to achieve its objective and move beyond the organizational limits of a traditional granting council has been adopted. Some of the elements of this framework are stated in the *Canadian Institute for Health Research Act*. The CIHR will have a president and governing council that will exercise overall governance for CIHR, which includes

13 institutes. A scientific director and an advisory board will lead each Institute. The CIHR projects that it is reasonable to expect that each institute it funds, when fully developed, will support a research program in the order of $20 million to $80 million per year, and will fund between 200 and 500 researchers. In forming these institutes or partnerships, the CIHR is attempting to strategically increase research in the health field. For example, in terms of partners such as the pharmaceutical companies:

> *That partnership is an attempt to catalyse ... and to make the name brand international pharmaceutical industry more research intensive in Canada and to get them to invest in research in Canadian universities and hospitals in this country. We have built various partnerships. They range from co-funding clinical trials, research on new drugs, new treatments —... you'll see that typically we would fund about 50¢ to $1 for every $4 or so that companies would put in — to funding chairs, in everything from women's health to clinical research paid for by the pharmaceutical industry in the country. The largest part actually is to train young investigators in clinical research.* [Allan Bernstein; 23, 11:40]

Canada Foundation for Innovation (CFI)

When it was first established in 1997, the CFI received an allocation of $800 million from the federal government. Since that time, there have been a number of significant additions to the funding for the CFI that brings total government appropriations to $3.15 billion. Furthermore, beginning in 2001, CFI funding was expanded to cover two new areas of endeavour. The first covers the funding of international infrastructure joint ventures that would provide Canadian researchers the opportunity to collaborate with the best in the world by helping them build and access facilities in Canada and abroad. The second covers the follow-on operating costs of new CFI-funded research installations and equipment. The president of the CFI explained the Foundation's investment intentions as follows:

> *The CFI invests major amounts of money in leading-edge research by putting in place the right working conditions to retain or attract top-quality researchers in Canada, training young Canadians for the knowledge economy, and supporting world-class expertise that will make Canadian institutes and Canada as a whole more competitive on the global scene. As you know, we explicitly support not-for-profit, non-government, research-performing institutions — not to mention, of course, the contribution all this research activity is making to the sustainable development, both social and economic, of many large and small communities across Canada. It is in this context that we operate.* [David Strangway; 10, 9:10]

On average, the CFI contributes 40% of total eligible project costs with the institutions; their other partners contribute the rest. Using this formula, total capital investment under this initiative will exceed $7 billion by 2010.

Some commentators have suggested that there may be some overlap or duplication between the mandates and investments of the CFI and the granting councils, but the Committee was told:

My view of NSERC is not an empire-building view. I recognize that we're middlemen, providing the money does go to the people who need it to do what is the right thing to do. Whether it comes through us or goes through CFI is immaterial. But the money should be where the pressure will be. [Thomas Brzustowski; 23, 11:05]

The proposals come from the institutions, and that makes us somewhat different from the other granting councils, where the proposals tend to come from the researchers. In this case, the universities sort out where they want their priorities and where they see their activities going, and then the proposals come to us from the institutions. However, once the proposals are received, they go through the peer process. … The proposals are measured on their own merit and how they fit the criteria. [David Strangway; 10, 9:25]

Given that the demand for CFI funds outstrips supply by a considerable margin — the Committee was told by a factor of three-to-one — rationing is required and funding decisions become critical. The Committee was told that this funding has and will be based on:

[T]he assessments of hundreds of experts from Canada and around the world, who review the projects on merit. … Our criteria for selection include the qualifications of the research team, the vision, the innovative capacity, the sustainability of the project, and the benefits to Canada. There is wide recognition of the integrity of the decision-making processes adopted by the CFI as being fair and transparent, free from any form of interference or intervention. This independence is essential, and the government is to be commended for having created this unusual governance model. [David Strangway; 10, 9:15]

This special governance model, however, is not without criticism. The Auditor General of Canada, for example, noted in his 2001 report that where the federal government had delegated decision making to a partner, such as the CFI, little reporting to Parliament on performance was done and, in other cases, there was a lack of "adequate measures to protect the public interest, such as complaint and redress mechanisms and rules on conflict of interest."[7] The Committee followed up on this criticism and drew the following responses:

Because the CFI is subject to somewhat different means of public accountability, we approach this aspect of our mandate very seriously. In fact, we even seek new, innovative ways to be accountable for the trust that the Government of Canada has placed in the CFI. For instance, we require annual progress reports for every project that we fund from each institution. These reports document the impact of the funding and explicitly lay out the benefits to Canada that are being achieved. The reports are posted on the website and form the basis for the annual review of the overall impact that the CFI funding is having in strengthening Canada's research excellence. They also provide a good look at the outcome of the research.
[David Strangway; 10, 9:15]

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7 Report of the Auditor General for Canada, *Reflections on a Decade of Serving Parliament,* February 2001, paragraph 96.

We also carry out third-party reviews of the impacts on the institutions and their researchers resulting from the CFI investment in support of their plans. We have put in place tight control mechanisms to make sure that funds provided by the CFI to the research institutions are used in accordance with our guidelines. Financial reports are required from the institutions and audit procedures have been established to ensure adequate and efficient use of CFI funds. [David Strangway; 10, 9:15]

The Committee, however, is not satisfied with these responses. In the Committee's view, the problem runs deeper and may be directly related to the special arm's length relationship with government. The Committee has been able to identify three areas of concern that need to be seriously addressed: (1) the evolving and expanding mandate of the CFI; (2) inadequate industry involvement in the research projects funded to date by the CFI; and (3) the accountability, transparency and Parliamentary oversight afforded this R&D funding vehicle.

Furthermore, the committee remains troubled that the Auditor General's second criticism — that of a lack of conflict-of-interest rules and mechanisms regar5ding complaints and redress when there are such significant taxpayer dollars at stake — is not being addressed. The Committee holds great sway with the peer-review process as a mechanism for ensuring "excellence" in research, but would also caution the S&T community at large that peer-review decisions on merit and excellence are not always purely objective; they represent the collective values of the people who are making the decisions. As a result, the Committee finds it disturbing that one of Canada's largest universities has received more CFI funding than the combined funding granted to the universities of Atlantic Canada, Saskatchewan and Manitoba. This inequity, the Committee believes, is symptomatic of the arm's length structure of the CFI from government. For these reasons, the Committee intends to review how the CFI's legislation is being carried out, including the current arm's length arrangement between the CFI and government, and the processes and criteria used in the funding decision making of the CFI in the fall.

Furthermore, the Committee remains troubled by the Auditor General's second criticism — that of a lack of conflict-of-interest rules and mechanisms regarding complaints and redress when there are such significant taxpayer dollars at stake is not being addressed. The Committee believes that the public interest needs further safeguarding when spending power has been delegated from government to private, arm's-length organizations and, therefore, recommends:

14. That the Government of Canada work with the Canada Foundation for Innovation in developing and implementing conflict-of-interest rules and mechanisms regarding complaints and redress consistent with that of federal government agencies.

CHAPTER 9: THE INTELLECTUAL PROPERTY RIGHTS REGIME

Intellectual Property Rights and Innovation

The creation of the intellectual property (IP) right has been an important industrial tool fostering innovation. However, its exact contribution is debatable, if not controversial. Society has long recognized that information, when held privately, rather than publicly, is a source of personal wealth. On the other hand, when such information is broadly available, it will likely be put to use by others and it will produce little, if any, wealth for the person who came up with the novel idea in the first place. Consequently, if individuals have little financial incentive to disclose a novel piece of information, they are not likely to make it public and entrepreneurs will not be able to make use of this private information. Needless to say, the economy and the quality of life will not be what it could otherwise have been.

Many societies, usually industrialized countries, have responded to this private-public incentive incompatibility by creating a property right in knowledge; a right similar to that assigned to other private property. This property right grants the holder the power to exclude others from its use in return for its disclosure and thus rewards innovative efforts commensurate with its commercial prospects. The Committee was informed on the practical usefulness of an IP regime:

> *[I]ntellectual property rights, as we all know, are meant to protect the investments that are made in innovation. The firms in our survey did indeed affirm their importance. They tended to use them. They tended to use patents and trademarks most frequently. And they did so most frequently when they were innovative.* [John Baldwin; 13, 9:20]

Exhibit 9.1 provides further facts and impacts of intellectual property, as uncovered by Statistics Canada business surveys. What this IP survey does not tell us, however, is that beyond the desire for innovation — innovations one might obtain without an IP regime — there is another fundamental reason to legislate IP rights:

> *On the one hand, innovations are costly to produce, but cheap to copy. So patents provide the incentive to innovate and to disclose information and also to exchange information through licensing. So even if there was no invention that we would have had anyway without patents, we still might want patents in order to get the firms to disclose their invention.* [Nancy Gallini, University of Toronto; 29, 11:05]

Exhibit 9.1
Innovation and Intellectual Property

- Only about one-quarter of the population of manufacturing enterprises, both large and small, make use of at least one form of protection.
- Only about 7% specifically use patents.
- The importance of the forms of protection increases with firm size.
- Being innovative is a primary determinant of the use of intellectual property.
- There are substantial differences in the use of trademarks, patents, trade secrets, and industrial designs between innovators and non-innovators.
- When the effect of being innovative is separated from the effect of size, nationality, and industry, innovativeness has its largest effect on the use of patents and trademarks.
- Although innovative firms concentrate on patents, they also use a wide range of other statutory forms of protection.
- Although many innovators make use of statutory intellectual property protection, there are a substantial group who do not.
- There are a number of reasons why firms do not seek to protect their intellectual property.
    - not all ideas imbedded in innovations are unique enough to be patentable.
    - Not all innovations are world-firsts.
        - Only 15% innovations are world-firsts. Almost 80% of world-first innovators protect themselves.
        - Less than half use patents.
- Process innovations are better protected through secrecy than products.
- Firms tend to value alternate strategies more highly than statutory forms of protection.
- Patents are ranked as a less effective strategy of protection.
- If firms are large, innovative, foreign-owned, and operate in the core or secondary sectors, the effectiveness of the statutory forms of protection (e.g., patents) increases greatly.
- Large firms use patents and trademarks more frequently than small firms; small firms use trade secrets more frequently relative to patents than large firms.
- Foreign-owned firms are more likely to make use of statutory forms of intellectual property rights and to value them more highly than domestically owned firms.

- Industry environment affects the use that is made of intellectual property.
- The core set of industries — chemicals, pharmaceuticals, refined petroleums, electrical products, and machinery — make greater use of almost all forms of protection than do other industries.
    - This is particularly true for patents and trademarks.
- Certain industries outside the core group are almost as heavy users of intellectual property protection as the core group.
    - The intensity of patent use in rubber and plastics is greater than the usage rate of firms in the core group.
    - Food, beverages, and paper products do not use patents very frequently but they have one of the highest usage rates of trademarks and trade secrets.
- Firms in different sectors take a very different view of the effectiveness of both the statutory and the innate forms of protection.
    - Firms in the core sector give larger scores to patents, copyrights, industrial designs and trademarks, and smaller scores to trade secrets.

Source: Statistics Canada, Catalogue 88-515-XPE, 1997.

Although inventors often have other means at their disposal for protecting against encroachment on their inventions — most notably, access to unique co-specialized assets or complementary "tacit" knowledge — many sectors of the economy depend heavily on the IP right to appropriate the benefits of their discoveries. These industries would include pharmaceuticals, chemicals, refined petroleum, rubber, plastics, electrical products and machinery. Moreover, although the government has recourse to other policy instruments that stimulate R&D, most notably research grants, contract research and research prizes, they all have their own specific design flaws that create economic distortions. For example, the first two research incentives may not go to the best or least-cost researchers and, no matter who receives the research incentive, they are rewarded on the basis of their input use (which opens the possibility of abuse by way of the various forms of "milking" the grant or contract extension) rather than on the outcome. Research prizes suffer from uncertainty in the credibility and decision-making capacity of the award-granting agency. So despite the potential for suboptimal use of an invention, IP has its virtues:

> *I would like to stress the nice thing about intellectual property is that it's decentralized. The market is the one to reward good inventions, and it punishes if the inventions are bad.* [Nancy Gallini; 29, 11:05]

> *The market system is an efficient means of processing information … [It] informs people where to invest in innovation in order to eventually realize a return on their investment and be adequately rewarded. In order for markets to work you have to have well-defined property laws and that includes well-defined intellectual property laws.* [Gwillym Allen, Competition Bureau, Industry Canada; 29, 11:05]

From society's perspective, then, the power to exclude others from the use of the knowledge uncovered and embodied in the property right, unless compensation is paid to the individual who discovered that knowledge, encourages rivals to innovate in return for the public disclosure of the discovery. Private information is therefore profitably made public. Yet a rivalry of the sort created by an IP right is not without its costs to society. All incentives for innovation, including the intellectual property right, suffer in varying measures from the *racing* environment created. First, the "winner-take-all" aspect of the tournament often leads to duplicative and wasteful R&D. Second, the power to exclude others results in a less than optimal pace of technological diffusion; however, without the right to exclude, there will often be nothing to diffuse. For this reason, an effective IP rights regime is often best accompanied by a strong and effective competition policy regime. Moreover, in a modern, developed and knowledge-based economy, such as that of Canada, the argument that there will be too much competition in R&D activities and too little competition in the use of the discoveries is less persuasive. The net benefits of an intellectual property rights regime are now demonstrably positive. What remains open to debate is not whether or not an IP rights regime should exist, but what level of protection should society confer to innovators through its IP regime; what level of protection is optimal?

In trying to come to an answer to this important question, one expert in the field suggested that before looking to strengthen Canada's IP regime, perhaps we should review the impact on patenting and innovation of: (1) past Canadian IP regime changes; and (2) recent U.S. legislative and judicial changes that have extended and strengthened patent protection much further than that granted in Canada today. These events can tell us much about Canada's current regime and whether or not innovation is efficiently stimulated by an extension or strengthening of such rights. This researcher's examination into the question drew the following conclusions:

> *[S]ince the mid-eighties and into the nineties, the rate of domestic patenting has increased. Now, on a per capita basis, it hasn't increased all that much. But what's more interesting than the rate is … who is doing the patenting, who is doing the innovation. … A lot of those innovations are foreign innovations and they came … [from the] U.S. because around the same time, since the early 1980s, the U.S. has really strengthened its patent protection. … [T]hey've broadened the class of things that can be patentable, like business methods and software and higher lifeforms. … It's not that the Canadian change has suddenly spurred innovation.*
> [Nancy Gallini; 29, 11:10]

> *Should we adopt a Bayh-Dole Act? … This is the act that has given the universities proprietary rights, patents on publicly funded research. We don't really have a Bayh-Dole Act in Canada. … I will say that of all the studies done in the U.S. about the effect of the changes in patent law on innovation …, they found that very little evidence can be shown that innovation has gone up except in those areas that are now patentable that had previously had not been patentable …*
> [Nancy Gallini; 29, 11:15]

[From] many Americans ... the message that was coming across is Canada does a pretty good job with their intellectual property. It's much more cautious about this balance between providing incentives to innovate and public access to invention. [Nancy Gallini; 29, 11:15]

The Committee concurs with these conclusions and is generally satisfied with Canada's current IP regime; it strikes a good balance between conflicting concerns and interests. That is, Canada's IP regime, as it stands today, confers the right amount of incentive to innovators, while generating much needed technical knowledge, and serves Canadian consumer interests in terms of access to modern products and services at reasonable prices. That being the case, the Committee does not preclude the possibility that some minor tinkering with the design of the current IP regime is worth considering.

Intellectual property takes a number of forms in Canada and elsewhere: patents; copyright; trademarks; trade secrecy laws; industrial designs; integrated circuit designs; geographic indication; and plant breeders' rights (see Exhibit 9.2). Dividing intellectual property according to these different categories allows the authorities to craft rules specific to the different circumstances of the property in question (while allowing some choice in the instrument to use) and thus reduces uncertainties in the marketplace over the delineation of rights and obligations. Because of time constraints and controversial issues outside the scope of this Committee that would encroach on other parliamentary committee work, the Committee chose to deal specifically with patents.

Exhibit 9.2
Intellectual Property Typology

Patent: is a property right in a new invention which grants its owner (patentee) the exclusive use, offer for sale, sale or importation of the product, technology or process (usually extends for a 20-year period from the date of filing (invention in the U.S.)).

Copyright and Neighbouring Rights: are moral rights, which include the right of authorship of works (expression of knowledge, databases, etc.), that protect its holders from infringement and unsanctioned reproduction and dissemination (usually extends for the author's lifetime and 50 years following death).

Trademarks: are distinctive marks used to identify and distinguish the goods or services of a business that protect its owners from infringement (usually seven years).

Trade Secrecy Law: adds legal processes and sanctions to the strategies available to an owner of information for preventing trespass by others.

Industrial Design Rights: grant protection for new and original designs of products (usually for a 10-year period).

Integrated Circuit Design Rights: confer similar rights for a topography, which is a design for the disposition of an integrated circuit product subject to certain limitations (usually for 8- to 10-year periods).

Plant Breeders' Rights: confer an exclusive right to sell and produce propagating material (seeds) of new plant varieties.

Geographical Indication Rights: are protections extended to owners of goods of a given origin, where the good's quality, reputation or any other of its characteristics is attributable to its geographical origin.

Patents and Patent Design

Intellectual property rights, in this case patents, possess the following attributes:

- eligibility for the right;
- duration of the right;
- breadth of the right;
- novelty requirement; and
- access requirements.

In short, the longer the duration, the greater the breadth, the more burdensome the novelty requirement, or the less imposing the access requirements entailed in the right, the harder it will subsequently be to "invent around" this invention, the less likely there will be follow-on inventions, and the more likely that potential competitors will be stifled. The converse is also true. This does not mean that the high technology or fast-paced innovative markets, whose firms may hold extensive patent portfolios, will be prone to monopoly; alternative products, technologies and production processes will remain a perennial source of competition over the longer term.

A number of theoretical debates on the optimal design of a patent right have focused on its three most basic characteristics: its duration, its breadth, and the renewal fee. In general, different industries have different needs in terms of the protection conferred along these three characteristics of a patent. For example, highly innovative industries, such as biotechnology, semiconductors and microprocessing, whose products become obsolete relatively quickly in today's marketplace, would prefer wider patent breadth and a shorter duration relative to the converse arrangement. So would inventors of a very popular product or service (precisely because success breeds competition). On the other hand, industries that are not innovating their products or processes frequently would prefer obtaining a patent offering a longer duration and narrower breadth than the converse. Another economic view holds that process innovation should receive wider or more breadth protection from an IP regime because this would counteract industry

incentives to engage excessively in product innovation since the resultant product differentiation tends to dampen price competition, whereas process innovation does not. These facts suggest that the IP authority might want to consider designing a menu of patent classes and types offering different levels of protection according to each characteristic, thereby allowing the inventors to sort themselves according to which better serves their interest.

In today's fast-paced innovative environment, another controversy has been brewing over aspects of the novelty requirement of IP. Innovations are increasingly seen not as discrete changes in technologies and products but as more incremental in nature. In this case, industries characterized by cumulative innovation have different needs because they are distinguished by an additional economic spillover, the so-called "standing on the shoulders of giants" benefit whereby the pioneering innovation essentially lowers the cost and increases the probability of making incremental or follow-on innovations. Again, in this case, the IP authority might want to consider addressing the design or strength of the novelty requirement. Here, we would pit the interests of the pioneering innovator against those of the follow-on innovators. On the one hand, the former would prefer a strong novelty requirement and greater breadth and, in its absence, he might consider the strategic value in not disclosing the original innovation and forego some early profit in order to have the advantage in making further incremental innovations over potential rivals and gain more profit later on. On the other hand, the follow-on innovators would clearly benefit from a weak novelty requirement and narrow breadth in order to avoid licensing or paying a royalty to the pioneer. A balancing of interests is thus required, but further attention must be paid to what is believed to be going on in the U.S. where the patents are seen as being particularly strong:

> *[S]urprisingly strong patents could reduce the amount of innovation if innovation is cumulative. … [W]hen I say cumulative it means builds on previous research, that in order to make a drug you need to understand the genetic composition and so you go from identifying the gene to eventually producing the drug. … [I]n that case the firms that get the first patents could possibly hold up future innovations. … There's tons of litigations going on among firms that have strong patent rights, preventing follow-on research, Texas Instruments is notorious for this. Firms are also engaging in wasteful patenting … in which they're patenting not for the innovation but so that they have bargaining chips to transfer to other firms to avoid litigation. So there's a lot of cross-licensing going on, for example, in the semiconductor industry.* [Nancy Gallini; 29, 11:10]

In practice, however, patent policy has focused on a 20-year term from the date of filing, with periodic ongoing maintenance or renewal fees, leaving the breadth, novelty, and access characteristics untouched. The Committee is unsure if this gap between theory and practice is because intellectual property regimes remain unsophisticated due to the political controversy they raise when suggesting change, or that there are practical problems yet to be, or that cannot be, worked out. In any event, there is merit in considering avoiding their "one size fits all" patent protection design.

The Committee received three suggestions for change: (1) expanding the eligibility to software products and some novel business practices under the condition of a much stricter novelty requirement (as in Japan) and a shorter patent life than is offered today; (2) a longer patent life (at a renewal fee) for goods, such as pharmaceuticals and drugs (as in Europe), that are subject to regulatory delay; and (3):

> *[T]he last suggestion might be to identify innovative sectors in Canada. Biotech, the high-tech sectors, computers are innovating quite a bit in Canada. And maybe we don't need a uniform patent policy, perhaps we should have differential protection in terms of patent breadth and length for those innovations.* [Nancy Gallini; 29, 11:20]

The Committee accepts these suggestions as legitimate changes for consideration, but believes that their cases have not been sufficiently made or, at least, have not been made to this Committee. A greater onus that would demonstrate either prejudice or innovation is being impaired in these sectors is required before extending this privilege. The Committee, therefore, recommends:

> **15. That the Government of Canada commit to maintain the current intellectual property rights and protection regime, while adopting the policy position that any non-trivial extension of any aspect of this privilege requires a demonstration of its net benefits to society.**

Intellectual Property Rights, Patent Pools and Competition Policy

IP laws and competition laws are two complementary policy instruments that promote an efficient economy. On the one hand, IP laws provide incentives for innovation and technological diffusion by establishing enforceable property rights for the innovators of new and useful products, services, technologies and original works of expression. Competition laws, on the other hand, safeguard these same efforts from anti-competitive conduct that would create or enhance market power or otherwise stifle rivalry amongst firms. In accomplishing the latter, Canada's competition law may impose limitations on the terms and conditions under which the owners of IP rights may transfer or license the use of such rights to others. There is not, as is commonly believed, some measure of friction between both policy instruments. In a competition law expert's opinion:

> *Once provided protection, society benefits from the application of the* Competition Act *to intellectual property for the same reasons that society benefits from the application of the Act to other property. Applying competition law to conduct associated with IP may prevent anti-competitive conduct that impedes the efficient production and diffusion of goods and technologies and the creation of new products. … Competition policy and intellectual property rights, rather than being fundamentally at odds with each other, … serve an overall complementary objective of fostering efficiency in a dynamic market environment. Both laws serve the common goal of promoting innovation and enhancing welfare.*
> [Gwillym Allen; 29, 11:20]

In general, the Competition Bureau — the agency responsible for enforcing Canada's *Competition Act* — will analyze whether competitive harm would result from a particular transaction or type of business conduct involving IP. This analysis has five steps:

- identifying the transaction or conduct;
- defining the relevant market(s);
- determining if the firm(s) under scrutiny possess market power by examining the level of concentration and entry conditions in the relevant market(s), as well as other factors;
- determining if the transaction or conduct would unduly or substantially lessen or prevent competition in the relevant market(s); and
- considering, when appropriate, any relevant efficiency rationales.

Underlying the enforcement approach taken by the Competition Bureau is the view that market conditions and the advantages IP provides should largely determine commercial rewards. If a company uses IP protection to engage in conduct that creates, enhances or maintains market power as proscribed by the *Competition Act*, then the Competition Bureau may intervene. To the extent to which some business behaviour serves as a conspiracy, bid-rigging, joint abuse of dominance, a monopoly-making merger and thus restricts competition among firms actually or potentially producing substitute products or services, the presence of IP would not be a mitigating factor. Such conduct would be subject to review under the appropriate general provision of the *Competition Act*.

The Competition Bureau was quick to support R&D collaboration and cooperation between some researchers that could potentially be competitive suppliers of the fruits of that research, but there are limits as in one case that is said to have occurred recently in the U.S.:

> *Two fronts worked … independently to develop laser eye surgery. At the end they finally got together and worked out some processes to perfect it and then formed what was called a patent pool and where they both individually had plans to sell the process or market the process in competition with one another in the range of … $400 to $500, and you couldn't have it done for less than $2,500. The Federal Trade Commission stepped in and broke up the patent pool and prices [subsequently] … fell … that's a situation where … the cooperation did not further the diffusion of the intellectual property. So that's one reason why you may not want them to cooperate.* [Gwillym Allen; 29, 11:40-11:45]

More generally:

> *[P]atent pools are a cooperation between firms to come into the market. There is a concern that all cross licensing that is taking place in semiconductors is like a barrier to entry because now firms can't enter unless they have a large portfolio of patents*

that they can trade in case of being accused of infringement. Also when firms are cooperating, they may suppress innovation. … If there are two substitutes that could be made, … then a patent pool would like to have just one of those because why increase competition in the market. So we could see prices going up … [Nancy Gallini; 29, 11:45]

However, one should not be too quick to condemn a patent pool:

Where we want to see the patent pools is where standards are important. If you just have competition in the market, what you could end up getting is one firm winning the standard race and that firm has an enormous amount of power. Through a patent pool, you pool the complementary assets, … and of course you want to make sure that everyone has access to the innovations in that patent pool and that leads to standards that no one owns. [Nancy Gallini; 29, 11:45]

The key here, then, is that the government (more specifically, the Competition Bureau) must remain flexible in its assessment of cooperative behaviour between potential competitors — in the form of patent pooling contracts — particularly when these patents involve complementary products and could lead to an industry standard.

Two cases of a transfer of IP rights that might lessen or prevent competition are when a licensor ties a non-proprietary product to a product covered by its IP right, and when a firm effectively extends its market power beyond the term of its patent through an exclusive contract. In either case, if the conduct leads to the creation, enhancement or maintenance of market power and would substantially lessen or prevent competition, the Competition Bureau may intervene. Some conduct that goes beyond the unilateral refusal to grant access to the IP could also warrant enforcement action under the general provisions of the *Competition Act*. The Committee would like to reinforce the term "may" in all of these potential interventions by the Competition Bureau because as an official from the Bureau put it:

In the 1970s … [i]t was also revealed that the contractual arrangements, such as exclusive dealing, tied selling and territorial market restrictions were capable of stifling competition in some particular circumstances, but often they were not, particularly with regard to intellectual property that the firms actually employed these types of contractual arrangements that actually stimulated competition and were pro-competitive. It was now understood that firms that license their intellectual property are rarely monopolous and that owning an exclusive right did not create a monopoly or market power … that flowed from the use of that property. [Gwillym Allen; 29, 11:20]

The Committee is satisfied that Canada's competition law treats IP consistent with the country's innovation interests and fully complements Canada's IP law.

CHAPTER 10: UNIVERSITY RESEARCH, R&D COSTS AND COMMERCIALIZATION

Canadian colleges and universities make significant contributions to Canada's social well-being and economic growth in three deliberate ways. First and foremost, they contribute directly to the nation's economic performance by educating and graduating highly qualified personnel to meet the increasing needs of the workplace; they expand the boundaries of knowledge in all disciplines through basic and applied research, as they develop concrete solutions to selective challenges of industry and government; and they contribute to the economic and social well-being of their surrounding communities.

The Committee intends to address the second of these three roles — basic and applied R&D — and will suggest ways of improving this contribution by colleges and universities without compromising the others. Indeed, because research and educating functions are highly complementary, as scholars who build on our stock of knowledge are better able to teach their students and students gain valuable experience when working with faculty on research projects, the Committee is convinced that its proposed commercialization agenda will financially assist colleges and universities at being better in all three functions.

University R&D Activity

Relatively speaking, Canadian universities perform more R&D as a percentage of total R&D undertaken in the country than do their counterparts elsewhere in G-7 countries, except Italy. In fact, Canadian universities accounted for 23.6% of all R&D activity across the country in 1998 (see Figure 10.1). Moreover, while outsourcing 5% of their total R&D to universities (see Figure 10.2) and financing 12% of university R&D (see Figure 10.3), Canadian firms rely more on the university as a source of innovation than do those of any other G-7 country. The university sector also co-authors an impressive number of research publications in collaboration with industry.[8] The quality of academic research and its efficient transfer to industry are, therefore, especially important in Canada.

At first glance, the impressive relative R&D performance of Canadian universities is particularly surprising given that the Canadian government's funding does not cover the indirect costs of the activity, whereas virtually every other major competitor country of Canada's does. However, on second thought, the relatively low GERD-to-GDP ratio, the smaller defence budget, and the lack of government funding of indirect costs of research oblige Canadian universities to seek and rely more extensively on the private sector for

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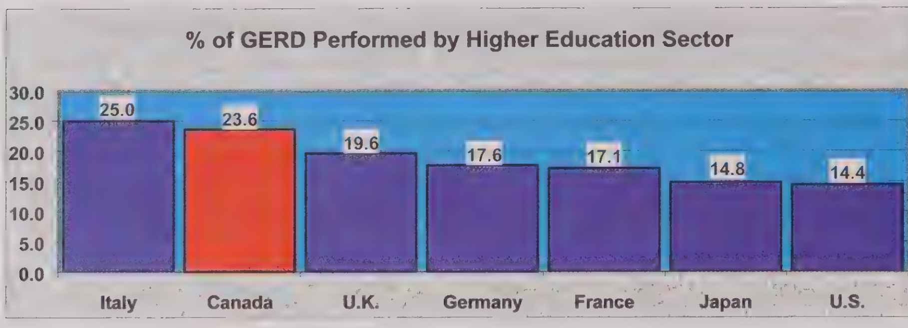
8 AUCC. *Trends, The Canadian University in Profile*, 1999.

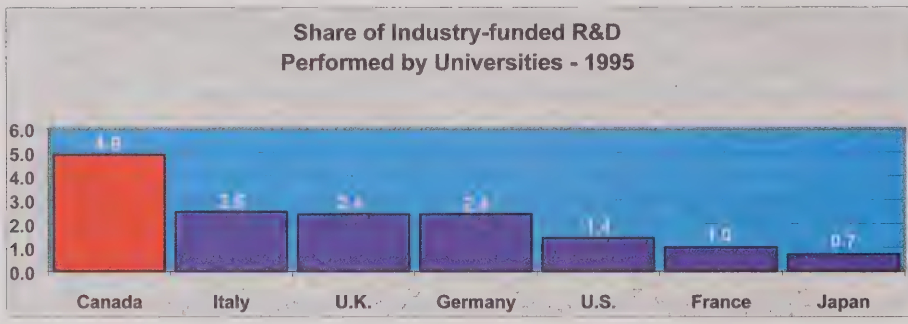
funding of its R&D activity. Paradoxically, then, this unusually great performance of Canadian universities in R&D is actually a cause for concern.

Figure 10.1



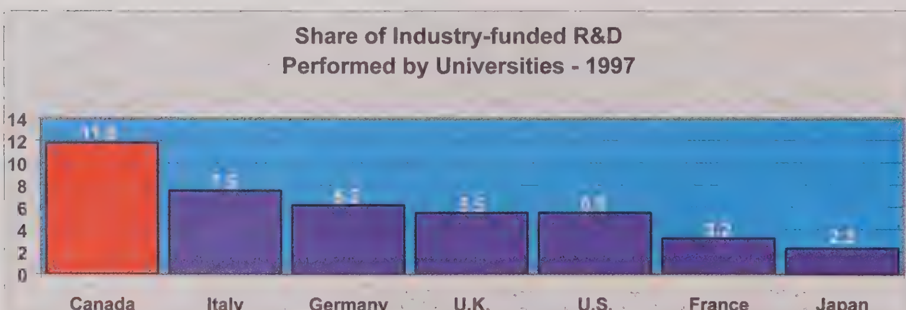
Source: OECD, Main Science and Technology Indicators, 2000.

Figure 10.2



Source: Pierre Fortier, Commercialization of University Research, 2001.

Figure 10.3



Source: Pierre Fortier, Commercialization of University Research, 2001.

Indeed, the Committee has discovered that the federal government's reluctance to cover the indirect costs of R&D when funding the activity has a couple very serious implications for universities. In the first case, the lack of coverage of the indirect costs of R&D means that a portion of the university budget that would have otherwise been allocated to students or capital requirements may have been diverted to R&D activities. Insufficient federal funding of R&D thus means that students and the community in which the university serves may suffer.

> *[…] — the principal investigators, the people without whom research would not take place — are paid for largely by the university. When I say university, I mean shorthand for university core funding as provided by provincial transfers and student tuition fees. That's what I mean by university. They are paid for by the Canada research chairs program and in 170 cases out of about 9,000, by the NSERC chairs program. The rest of the professors, then, are paid out of university budgets.* [Thomas Brzustowski; 23, 10:36]

Secondly, there are implications for research capacity in Canada, particularly among Canada's small universities:

> *[A] number of us from NSERC, from our senior management visited 11 universities in Atlantic Canada and 5 in the prairies to find out what their problems are in capacity building and our conclusion was ... They simply for whatever reason don't have those facilities and the capacity to provide those services. We believe that capacity building in the smaller universities needs to focus first and foremost on providing these services. That will allow the faculty members there to become more productive and succeed better in the national competitions.*
> *[Thomas Brzustowski; 23, 10:40]*

Where the Committee departs from this view is that we posit a reason why small universities do not have "the facilities and the capacity to provide these services." We believe there is a causal connection between the lack of federal funding of the indirect costs of R&D and capacity to undertake R&D, particularly at the smaller universities across the country. This is not the only reason for insufficient research capacity — for example, the lack of a well-established graduate program at some small universities would be an issue — but it likely is a significant contributing factor.

Among the experts appearing before the Committee, it was unanimous that before universities could contribute further to the federal government's innovation agenda that would double the amount of research done in Canada, we must first address the shortfall in funding of the indirect costs of R&D.

> *[U]niversities have reached a point at which they will no longer be able to sustain federally sponsored research unless the issue of indirect cost is substantially addressed.* [Robert Giroux; 23, 9:30]

In fact, all higher education stakeholders appearing before the Committee said that they welcomed the new programs for support of research such as the CFI, Canada

Research Chairs Program, Genome Canada, and the Canadian Foundation for Climate and Atmospheric Studies, but that this funding brings both new work and a new administrative burden that costs them real dollars, in some cases dollars they do not have.

> *We will not be on a level playing field with our major adjacent competitor until the issue of indirect costs is met. Our universities and research institutes across the country have a significant role to play in the innovation agenda. We need to be equipped to do the job. Provision of indirect costs will allow universities to upgrade their information technology services for transfer of research data, and to take advantage of the high speed communication links between institutions; to upgrade animal facilities; to provide for safe, high quality animal care for assessment of new treatment methodologies; to provide better support for human ethics reviews; and to provide the administrative support for more rapid uptake of the proved projects. In addition, information on library resources for researchers will be able to be adequately supported. That is the kind of equipping universities and their research institutes need to be competitive.* [Bruce Hutchinson, Canadian Association of University Research Administrators; 23, 9:25]

These costs are also more constraining at the smaller universities:

> *[I]n addition to reimbursement of the indirect cost of research, smaller universities will require assistance to develop their research capacity in a sustainable way. As you well know, the potential to innovate exists in all of our 92 universities across the country. Many of our smaller universities consistently demonstrate that they can excel by exploiting their strengths. No one institution or region owns the monopoly on good research ideas. They can, and should be encouraged in all parts of the country. It is time for a federal initiative that would develop sustainable research capacity and enhance underdeveloped research within smaller institutions to serve that purpose. This initiative would allocate funds to smaller institutions on a competitive basis to help them establish the foundation and addresses the challenges they face in building regional programs or initiatives that reflect both institutional and regional priorities.* [Robert Giroux; 23, 9:35]

The Committee agrees with these university research stakeholders that this historic oversight in the funding of university research must be redressed. The Association of Universities and Colleges of Canada (AUCC) contends that the federal government should reimburse universities for their indirect cost of research at a nominal rate of 40% over and above the direct costs, and would have this rate adjusted upwards for smaller universities to reflect their higher cost structure. The Committee, however, will not put an exact figure on such a proposal, but will instead provide a general economic formula for covering all the costs of university research. The Committee recommends:

16. That the Government of Canada analyze the direct and indirect research costs at Canadian universities and colleges. Based on this information, the Government of Canada and provinces negotiate a new funding agreement that would take into account direct and indirect research costs and also the differential between large and small universities and colleges.

Research grants on this basis should allow the principal investigator to negotiate a reduction in his teaching load to pursue his research interest without imposing an undue burden on the remaining teaching resources.

The Committee also has other, more general, concerns with the current levels of funding afforded post-secondary education. The present Canada Health and Social Transfer (CHST) may not lend itself to the kind of targeted transfer needed to increase the capacity, and improve the infrastructure, of our universities and colleges. The Committee will, therefore, examine this aspect of post-secondary education and research in the fall.

Canada Research Chairs

The Government of Canada, in its budget for year 2000, provided $900 million to establish and sustain 2,000 Canada research chairs that would be administered by the three granting councils. Under the Canada Research Chairs program, these new research positions were created to strengthen degree-granting institutions across Canada — from large universities with research strengths across a variety of disciplines to smaller institutions with more focused research capabilities. About half of these positions would seek to attract established world-class researchers and the other half would seek to support those institutions that have demonstrated the potential to achieve world-class standing in their area of research.

The program's key objective is to encourage the building of a critical mass of world-class researchers in order to help Canadian universities achieve research excellence. Universities were to develop comprehensive plans describing their research priorities and strategies. Applications from universities for individual positions would be evaluated against these strategic plans by review panels established by the granting councils.

Events following the announcement of the Canada Research Chairs program have been troubling to the Committee. The preponderance of research positions was allocated to the largest of universities, with 6% going to smaller universities. While the exact allocation process was not explained to the Committee in detail, we were told that it was largely based on past performance or past competitions for research grants:

> *[T]he distribution of the research chairs was based on the university's success in the past in granting council funding … AUCC made strong representations at the time to have a different distribution so that some of the chairs that would have been going to the more successful universities would be going to the smaller universities. We have succeeded partially, maybe not as much as we could, but there has been a redistribution of the chairs towards the smaller universities on that basis.* [Robert Giroux; 23, 10:10]

Apparently, the government perceived the research capabilities of smaller universities as deficient in some way. When it was realized that this was unacceptable, a quota was established:

> *[T]he government being sensitive to it, 6% of the research chairs were allocated to the smaller institutions, which meant 6% more chairs were allocated to them than would have been allocated had we gone on a straight proportional allocation of the chairs, the overall.* [Robert Giroux; 23, 10:15]

This decision was then described as a great accomplishment:

> *[T]he Canada Research Chairs Program is quite exceptional precisely because of this concern, which at the beginning was to set aside percent of the research chairs for small universities. That was truly an excellent decision. In fact, when you think about a small university with 4,000, 5,000 or 3,000 students, that receives 5 or 6 research chairs for $200,000 per year over a seven-year period or $100,000 for five years, it would need 3 million dollars in capital to establish such a chair. For a small university that receives 5 or 6 chairs, that can make a huge difference in its research ability and leadership in research.* [René Durocher, Social Sciences and Humanities Research Council of Canada; 23, 11:50]

The Committee is unable at this time to determine if the allocation of the 2,000 Canada research chairs was handled in an equitable manner, but it does believe that the apparent method chosen raises serious concerns on grounds of efficiency — that is, on whether the best or least-cost way of expanding capacity is being taken. Because the research chairs were created as one component of an innovation agenda — an agenda focused on the future — it seems rather contradictory to allocate these positions based on historical performance. Using past performance as a decision criterion means the future is condemned to reflect the past, which we know in advance favours large universities with strong research capacity over small universities with poor capacity. It is not surprising, then, that these Canada research chairs, which were touted as a way to build new research capacity at Canadian universities, ended up mostly in the hands of large universities, thereby simply reinforcing, if not augmenting, the existing disparity in research capacity across the country. This disparity may further be compounded by the larger universities raiding the smaller universities for their best and brightest faculty members. Knowingly tilting an already “unlevel playing field” further towards large and against small universities clearly calls into question the “set of values” held by these decision-makers.

The Committee would have preferred to see these positions offered up in an open competition to the best bids based on transparent and legitimate research plans and capability criteria. If it were thought that this method would still be biased towards the larger universities, then the 6% quota for smaller universities would have remedied the inequity consideration. In this way, the 94% of research chairs won in the open competition, whether won by large or small universities, could not be subject to criticism on efficiency grounds without calling into question the criteria (something that could have been handled by a request for comment from the stakeholders at the outset). The primary

difference between what the Committee proposes and what appears to have happened is the orientation of the decision: ours focuses on the future, which is the direction to which our policy compass should be pointed.

The Committee could not, because of time constraints, pursue these concerns at the present time. When it examines the granting councils in greater detail this fall, the Committee also intends to pursue the distribution of the Canada research chairs.

Commercializing University R&D

For many higher education stakeholders, the commercialization of university research is an area of concern; it preoccupies the Committee as well. At the outset, and as was stated above, the Committee believes that universities and colleges have three roles to fulfil and we do not want to see one being compromised for the other. At the same time, and as the Committee recommended in its earlier report entitled *Research Funding: Strengthening the Sources of Innovation*, Canadian universities and colleges need to strike a proper balance between the amount of basic and applied research they do.

The Committee was told that Canada scores well on some terms of commercialization, but scores poorly on others. For example, according to Statistics Canada's latest survey,[9] a total of 52 AUCC members are actively engaged in the management of their intellectual property. Together, these institutions account for 98% of sponsored research in Canada.[10] The most recent survey undertaken by the Association of University Technology Managers confirms that Canadian universities are making a solid contribution to commercialization, notably in terms of invention disclosures, licences executed, and spin-off companies created.[11] These results are viewed as more remarkable given that the environment for commercialization activities in Canada is less favourable than in the United States; the U.S. is described as the world leader in this regard, principally due to the *Bayh-Dole Act* of 1980.

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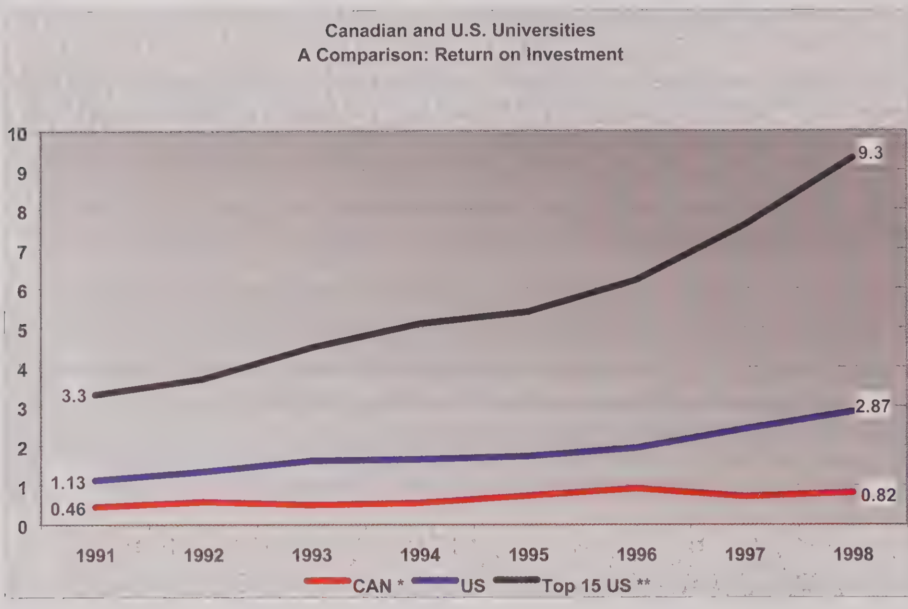
9 Statistics Canada. *Survey of Intellectual Property Commercialization in Higher Education Sector*, May 2000. p. 5.

10 Advisory Council on Science and Technology, *Public Investments in University Research: Reaping the Benefits*. Report of the Expert Panel on Commercialization of University Research, 1999, p. 11.

11 This is in proportion to the total sponsored research expenditures.

Figure 10.4



Source: Pierre Fortier, Commercialization of University Research, 2001.

The favourable U.S. position relative to Canada shows up in the return on investment data as depicted in Figure 10.4. Colleges and universities in the U.S. have a return on investment approximately three times greater than that of Canadian universities. In looking to the United States as an example, it was suggested that:

> *[O]ne of the key policies which was made in 1980 was to pass legislation to say from now on when researchers develop intellectual property it won't belong to the government, it will belong to the university where the research is performed with the obligation for that university to organize a commercialization office and to commercialize and to do it in such a way that it favours the American enterprises and preferably the SMEs …* [Pierre Fortin, Commercialization of University Research Panel; 23, 9:40]

On this point, the Committee was told:

> *[L]arge universities, research-intensive universities in Canada, already have policies that support commercialization of research from university inventions. Some of them have been very successful. I just wanted to talk about three examples. I think we would all recognize one is the University of Waterloo where the inventor owns. Another would be University of British Columbia that's been quite successful where the university owns and my own university, Queen's University, that has been quite successful in commercialization of research where again the inventor owns and we have agreement around how one can commercialize research and get benefits from that. So I think we would all point to those three examples with different policies*

having a significant impact on their local economies and on commercialization of research. [Bruce Hutchinson; 23, 9:50]

It was further suggested something similar should be adopted in Canada:

> *There is a need to have a benefit-to-Canada clause. There is a need for researchers to disclose federally funded IP that they commercialize to their universities, which in turn must disclose it to the government. We have to have a policy on IP ownership. There is a need to have incentives and universities must submit policies which adequately reward innovative researchers for federal approval.*
> [Pierre Fortin; 23, 9:10]

Many universities in Canada, however, are not prepared in terms of commercializing their research results:

> *Since a number of members of our organization are involved in commercialization of research, I would be remiss not to indicate our support for assistance in the commercialization of research from universities. While a small number of universities could claim to be internationally competitive, the majority are not equipped at this time to build on their potential to contribute to the regional and national economy.* [Bruce Hutchinson; 23, 9:25]

For this reason, most witnesses appearing before the Committee recognized the need for, and supported the development of, a commercialization policy in Canada:

> *[W]e do support commercialization. … In fact, we do cite statistics and we say that if all the right policies are in place, if the right kind of support is in place and that includes very much the indirect costs and the capacity of the smaller institutions we feel universities can triple the situation that they're in right now and that of course are patents and licensing and spin-off companies and a number of these activities, and particularly, the revenues that they get from commercialization.*
> [Robert Giroux; 23, 9:45]

However, within the teaching community there is a spectrum of views beginning with those who believe that teachers and universities should have nothing to do with the IP business to those who will "fight tooth and nail" to preserve their right to create and protect their IP. The first camp holds that:

> *Neither individual professors nor universities should own the knowledge they create. It's paid for by the public. … [I]t should go directly into the public domain. The first concern is that if you treat the results of academic work simply as property, scholarly communication is going to suffer greatly. The worry is that professors will become more interested in keeping quiet about a discovery in the hopes of making a profit off it than in sharing the knowledge they've created … The second concern … is that when universities focus simply on creating products or creating intellectual property, they abandon the tradition of university research in the public interest.* [Paul Jones, Canadian Association of University Teachers; 29, 11:20]

The second camp holds that:

> *They want to preserve [their IP], to exploit them. They see these rights as a legitimate recognition of the work they've done, the scholarly toil they've engaged in. … "Every prof a millionaire" is one of their rallying cries.* [Paul Jones; 29, 11:25]

The Committee recognizes that there is no unanimity on the question of whether to commercialize or not. However, the Committee is fully aware that the framing question is not whether university and/or professors should commercialize or not — because they can commercialize, and indeed have done so already, without the federal government's say — but whether there should be laissez-faire or rules and/or guidelines governing commercialization efforts of universities and scholarly professors. There are merits on both sides of this question; however, the Committee sides with the need to develop a commercialization policy of university research in the hope of improving Canada's record at turning good ideas into products and services, as well as ensuring commercialization efforts do not overtake public interest concerns on producing the knowledge workers of tomorrow. Although the Committee is not at this time in a position to suggest the specific components of such policy, we recommend:

17. That the Government of Canada, after consultation with the provinces, develop a comprehensive policy on the commercialization of university and college research that would include rules on disclosure, ownership of results and administration issues.

CHAPTER 11: FINANCING INNOVATION START-UP FIRMS

Small start-up companies are key sources of new ideas and industrial innovation and, not surprisingly, are gaining prominence in the innovation system. In emerging areas where demand patterns are not settled, the technologies are not fully worked out and risks are substantial, small firms are outperforming large firms by a wide margin. Small firms have the advantage under these difficult conditions because they are decidedly more flexible, more focused and provide a better combination of incentives for fostering creativity than their larger counterparts. Clearly, a country characterized by a greater number of innovation start-ups and business success stories will gain the advantage in the knowledge-based economy and it is for this reason that the Committee will next explore the uncharted challenges facing innovation start-up companies. We will begin with their access to venture capital, followed by a review of the elements required to form a successful cluster of these extraordinary start-ups, and finish with the National Research Council's (NRC) forays into incubating innovation spin-off companies and coordinating the development of innovation clusters in Canada.

Innovation Start-ups and Venture Capital

Finance is the lifeblood of any enterprise but, for any new enterprise, it can often be the critical difference in whether and how a good idea is turned into a novel product, service or technology. Finance, which one may think is the least problematic of factors for a person with a great idea or innovation a priori, can, in the end, turn out to be the most critical factor. In fact, financial matters can be pivotal precisely because the development or sophistication of Canada's capital markets at the venture end of the financial capital market spectrum has been found to be somewhat lacking relative to our major competitor country, the United States. One venture capitalist maintains that the current demand and supply imbalance for venture capital is precarious, if not alarming.

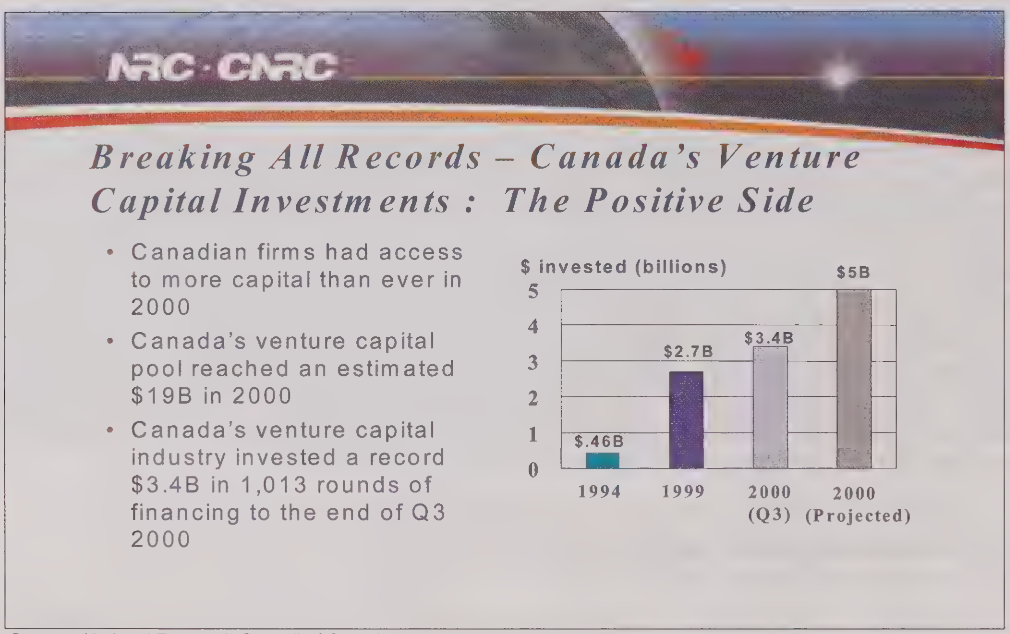
> *[T]he venture capital industry in Canada has less than one year of cash. So although it's growing, the fact of the matter is, in my view, it's in a perilous position because we are having these unprecedented numbers of new company start-ups and company growth and suddenly they're going to hit a brick wall if the money isn't there.* [Calvin Stiller, Canadian Medical Discoveries Fund Inc.; 29, 9:35]

There also appears to be a regional dimension to this demand-supply imbalance:

> *[T]here is a severe lack of venture capital funding for new ventures, new start-ups, etc. in some regions of the country, particularly Atlantic Canada. … [T]here are opportunities there but it's very difficult to get VCs [venture capitalists] to look at Atlantic Canada. There's still this situation where many banks and VCs … [are] not really interested in the true start-up, which has no assets, no cash flow, except, perhaps, for IP and people. Canada has relatively few VC investors compared to the*

United States, though, again, that's changed dramatically to the positive in the last three or four years. [Arthur Carty, National Research Council of Canada; 29, 9:20]

Exhibit 11.1



Source: National Research Council of Canada.

This improvement in the past few years was backed up statistically and is presented in Exhibit 11.1. Canada's venture capitalists are financing more than ten times what they were just seven years ago and, in 1999, 80% of their investments were in new technology companies:

Field	Investment	Percentage
computer-related	$982 million	(36%)
communications	$359 million	(13%)
biotechnology	$315 million	(12%)
electronics	$262 million	(10%)
medical/health	$159 million	(6%)

The root cause of the problem is often stated as follows: the process of bringing new ideas to market presents more difficulties than financing an ongoing operation. The newness of the product means that the market's acceptance is uncertain and the financial institution bringing the product to market must go to greater lengths in predicting this reception. This situation implies that the financial institution faces both more risk and a

higher degree of uncertainty about the nature and magnitude of this risk compared to financing ongoing business operations. Unfortunately, the talent prepared to work at the venture capital end is scarce in Canada, and a thin supply side has led to modest government intervention. Both the Business Development Bank of Canada (BDC) and the National Research Council of Canada (NRC) are engaged in different ways in the venture capital business.

The Committee was also told that there is another side to this picture:

> *Often the failure of small companies is due to the fact they can't access financing, for example, venture capital. They need very strong management skills and that's sometimes a shortcoming in Canada. Obviously they need highly qualified resources, human resources. They need advice and mentoring. Incubation is a great help to small companies to help give them that oxygen which is so crucial to their nurturing and growth ...* [Arthur Carty; 29, 9:05]

A lack of highly skilled managers in small businesses in Canada also adds to the risk the financial institution must screen for and bear when taking products to the market for the first time.

Capital markets adjust to these risky opportunities in a number of ways, most notably they specialize at the various stages in a start-up company's development. As a result, there is differentiation among venture capitalists, a kind of "stratification of capital suppliers." Hence, the market has an order from seed capital to expansion capital to mezzanine capital to junior capital and finally to senior capital stages, whereupon a start-up company graduates out of the venture capital range and is ready to undertake an initial public offering (IPO) to one of Canada's stock markets. Along this venture capital continuum:

> *Seed investment is a different type of venture capital than expansion capital. Expansion capital is different than that mezzanine, and the junior capital markets are different than the senior capital markets. Are any of them the answer? No. It's a continuum.* [Calvin Stiller; 29, 10:25]

Other strategies employed by venture capitalists include representation on the start-up company's Board of Directors, maybe even suggesting a manager of operations, and measured financing at different stages of development.

> *Little amounts of money don't work in venture capital. You can invest a small amount of money but you need to be there for future rounds. It needs to be an effort of trying to get funds in very small amounts, $200,000, $300,000, but those are just the first rounds. If it's a successful technology, you'll find yourself needing $2 million or $3 million just to stay with the rounds that could ultimately raise $10 million or $15 million or $20 million.*
> [David Mowat, Vancouver City Savings Credit Corporation; 29, 9:20]

The BDC also reports that, in their sample survey, "venture-backed companies that have gone public consumed an average of $23 million in private capital before embarking on their IPO." This survey also indicated that:

> *Venture capital investors have provided, on average, 37% of the total equity in the private companies ..., allowing them to play a meaningful role without assuming control. The founders themselves had a substantial stake — 28% of the equity capital — directly aligning their interests with those of their investors. Corporate investors continue to play a significant role in this market, providing 24% of the equity to private companies while private investors accounted for another 6% of the total. The final 5% of equity has come from employees, governments and universities.*[12]

There will also have to be an exit strategy for the venture capitalists upon or after the start-up's graduation to the major stock market ranks, so we are talking about ten years of development under the wings of venture capital.

It was suggested that the tax modifications or enhancements would to some extent alleviate the demand and supply imbalance, specifically:

> *[T]ime honoured for developing resources in the ground over the last many decades out west was flow-through shares and it was wonderful. It wasn't tax loss; it was tax deferral if profit didn't come. Why we don't do that in the area of research and development is beyond me.* [Calvin Stiller; 29, 9:40]

The Committee believes the reason that the federal government appears reluctant to develop such a tax instrument has been related to the long-standing problem of defining R&D activity for tax purposes. Nevertheless, the Committee prefers the government's current strategy of directly attacking the capital market gap through the activities of the BDC. Moreover, in many ways we are not just describing a capital supply problem but a coordination problem, which the Committee will next broach.

Innovation Clusters and the Coordination of its Elements

What comes through loud and clear from all stakeholders of Canada's innovation system is that much success in starting up innovation or new technology companies is related to the development of innovation clusters: geographically concentrated industrial centres containing a number of elements (see Figure 3.1). Contrary to the popular myth that Canada's business sector does not have an entrepreneurial spirit, the Committee was told that: "I take real issue with the idea that the DNA of Canadians is deficient of the entrepreneurial gene. ... The Canadian genome has that entrepreneurial gene there." [Calvin Stiller; 29, 9:35] What appears to be missing is some form of integrating force or coordinating function bringing the requisite elements together.

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12 Business Development Bank of Canada, *Economic Impact of Venture Capital*, 2000.

We hear about a lot of success stories. I think if you're looking for areas for improvement, we really still have three solitudes. We have people, there's money, and there's technology. In Canada, we have a pretty good supply of all of them. What we aren't able to do often is get them together, and either get the people mentored, get the money in the right places or get the technology backed by the proper people and the proper money. [David Mowat; 29, 9:20]

Evidence of these three solitudes is found in one particularly important industry in Canada's future, i.e. biotechnology, and the problem was described in the following way:

I was asked to speak in front of a major venture capital fund in Canada … and it was Genetics 101. They were really starting 20 years behind their counterparts in the States. That was five years ago. [Allan Bernstein; 29, 11:20]

Furthermore, evidence was found to exist in some of the more traditional sectors of Canada's economy: the automotive sector, for one. Windsor is the centre of research in the automotive industry — at least the majority of research — which happens to be 50 to 100 kilometres from the large research centres of Michigan, where the automotive company head offices are located. Windsor is a clear strategic choice of industry, yet the NRC is proposing an additional automotive research centre be located in London, Ontario, which is more than 180 kilometres north of Windsor. So the application of the cluster strategy in the automotive sector seems to be going awry, as the various parties seem to be headed off in different directions.

Technology Transfer, Incubation and Spin-offs at the NRC

The newly or re-engineered NRC now takes what can be described as an aggressive or entrepreneurial approach to stimulate innovation in Canada. Its president listed just some of the Council's accomplishments in this area:

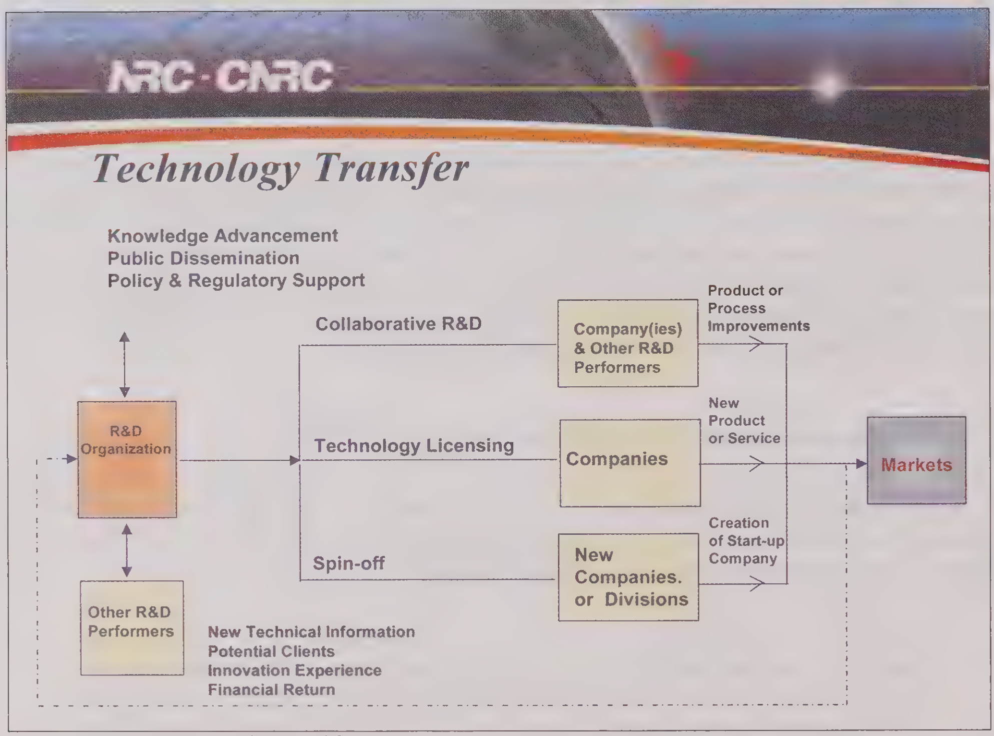
In terms of NRC itself, since 1995 we have actively pursued the creation of new companies and new businesses with our intellectual property, our technology and our knowledge. You can see that this is a growing activity. We have created about 45 new companies over the last five years and about 40 of those are new startups and spinoffs … [Arthur Carty; 29, 9:05]

About 150 estimated spinoffs from government labs, including I might say, 110 from the National Research … and … there are … close to 800 university spinoffs in Canada. They generated about $2 billion in sales and about 12,000 jobs. Our own estimates of NRC spinoffs alone put it at about 7,000 employees—over a considerable period of time of course—and $1.2 billion in annual sales. [Arthur Carty; 29, 9:05]

These accomplishments flow from the NRC's incubator program or strategy. This strategy transfers technology to industry in one of three ways (see Exhibit 11.2). The collaborative research route involves the sharing of funding and management of medium-

to long-term research with industrial partners (may involve more than one company, as well as university partners). Researchers work side by side with NRC teams. The NRC also grants industrial clients the right to exploit NRC-developed technology for a specified period and area of application. This licensing route sometimes grows out of collaborative research efforts and generally results in revenues that flow back to continue the cycle of discovery to innovation to market. However, the fastest technology transfer or commercialization method is the spin-off or start-up company route, whereby the NRC provides various forms of support — training, advice, management and financial.

Exhibit 11.2



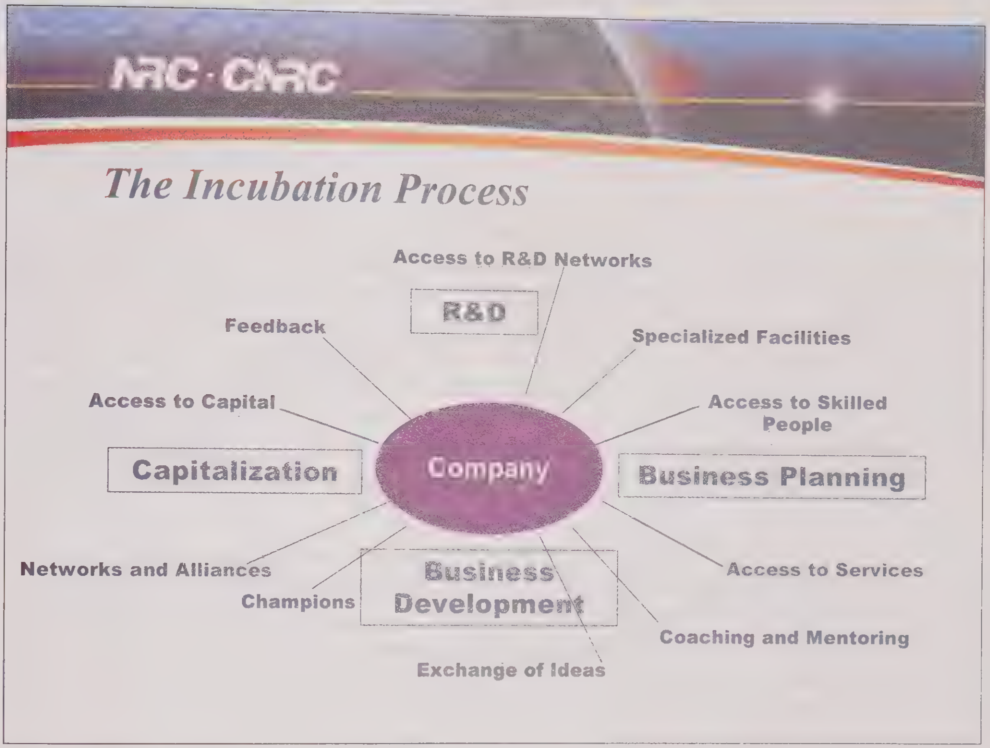
Source: National Research Council of Canada.

Most of the NRC's research institutes have the means to incubate small technology-based firms. Co-location at NRC labs contributes significantly to the process and there are more than 65 incubator tenants at the NRC today. Exhibit 11.3 displays the elements and activities of the incubation process, but it was described to the Committee in the following way:

> *I just show you some idea about the incubation process. Here in the middle is the company, the new start-up, the spinoff, and it needs … access to R&D, business planning, capitalization, business development. It gets synergy from other companies which are in the incubator. Of course the capital is there. There are services that can be provided, networking services for example, coaching and*

mentoring. This is the idea of the incubator providing the oxygen and the wherewithal for these companies to survive, to get the impetus and to grow to be medium and large companies. [Arthur Carty; 29, 9:10]

Exhibit 11.3



Source: National Research Council of Canada.

The Committee is overwhelmed by the entrepreneurial partnerships the NRC has forged with industry and believes that these successes, while too numerous to mention, are an intriguing and effective way of tackling the problem. With the BDC attacking the venture capital gap from the financial side and the NRC attacking it from the technology transfer side, much success is expected. Working in tandem, perhaps the BDC and NRC together could spur innovation in all regions of Canada. The Committee, therefore, recommends:

18. That the Government of Canada direct the Business Development Bank of Canada and the National Research Council of Canada to develop and implement a joint incubation/technology-transfer assistance strategy. The strategy should encourage private venture capital and labour-sponsored fund participation.

CONCLUSION

Canada and the industrialized world are in the midst of transforming itself into a knowledge-based society. The so-called *Information Revolution*, which has been unfolding for at least the past 20 years with more still to come, will in all probability be reinforced and outdone by the nascent biotechnology revolution that is underway. The next generation of Canadians will likely lead quite different lives than Canadians today and the demands imposed on them, particularly in terms of acquiring knowledge and being socially adaptable, will be far greater.

Canada's recent record in acquiring knowledge relative to other OECD countries has been impressive: our educational investment record is superb; our scientists are among the most productive in the world and have distinguished themselves in a number of fields, which are likely to be key catalysts of the biotechnology revolution. So, on this score, Canada is well placed to be a leading economy in a knowledge-based world. If there is weakness, it is on the R&D front. Canada trails virtually all G-7 countries (leads only Italy) and most West European countries in terms of its expenditure on R&D relative to GDP. Indeed, what is surprising is Canada's relatively high standing in terms of productivity and standard of living in light of its laggard R&D performance.

This somewhat paradoxical finding suggests that Canada, although blessed with highly productive and successful scientists, has and employs too few of them. Perhaps, more than anything else, it is a reflection of the twin facts that Canada relies heavily on FDI and that R&D tends to be a centralized activity of firms. This results in innovation being too narrowly diffused about the country; essentially, it flows strictly from U.S. parents to their Canadian subsidiaries, leaving those Canadian domestic SMEs, particularly those without a global mandate to strategically seek foreign markets, too technologically far behind their rivals. Although Canadian-owned SMEs have been developing networks of excellence of their own to climb their way out of this "innovation gap," their productivity remains too low and they are falling further behind.

Canada's historical pursuit of comparative economic advantage in exploiting its natural resource base — industries that are very capital intensive — and its consequent reliance on foreign capital, while successful, will be challenged in the twenty-first century. The Committee does not mean to suggest that Canada should abandon this historical pursuit. Indeed, Canada's large geography and diverse geological topography will ensure that it remains relatively well endowed in natural capital and will be a net exporter in natural resources forever. Be that as it may, the composition of Canadian industry will likely continue to change towards more R&D-intensive products and services. The knowledge-based economy to which Canada is headed demands that we lose this highly specialized economic status and move beyond such a simplistic strategy.

In this vein, Canada's industrial structure is responding to these new realities, probably more than any other major OECD country; the evidence being that Canada is the sole OECD country in the past decade to show R&D-to-GDP increases largely due to a shift towards more R&D-intensive industries. Without any national policy guidance, industry has been boldly adapting to the new prevailing circumstances. The final step is to have the Government of Canada join this effort in a substantial and meaningful way. In fact, government needs to refocus its industrial strategy towards the pursuit of more R&D-intensive activities and industries.

The Committee recommends two avenues of pursuit: (1) the federal government should ensure more R&D is done in Canada; in fact, the Committee endorses the government's target of being within the top five R&D performers in the world by 2010; and (2) the federal government should broaden its current innovation targets to include indicators of commercialization and diffusion of Canadian and world R&D. The Committee also set out a research agenda for itself to delve deeper into specific areas of concern.

Along the first avenue, the Committee recommends that the federal government: (1) actively pursue FDI from R&D-intensive industries; (2) increase its funding of not-for-profit and for-profit private sector R&D, which would include paying universities for the indirect costs of research, and improving the scientific research and experimental development tax credit system for SMEs while broadening the Technology Partnerships Canada investment portfolio rules; (3) facilitate R&D partnerships and collaboration through the National Research Council's cluster strategy; (4) restructure the current governance structure for federal science and technology within government by transforming the Secretary of State (Science, Research and Development) to a Minister of Science and Technology; and (5) develop a definitive advisory process for large scientific research projects, particularly those with an international component.

Along the second avenue, the Committee recommends that the federal government: (1) develop a comprehensive policy on the commercialization of university and college research that would include rules on disclosure, ownership of results and administration issues; (2) immediately double the funding of the National Research Council's Industrial Research Assistance Programfor Canadian SMEs; and (3) improve Canada's record in financing innovation start-up companies through the development of a joint National Research Council and Business Development Bank incubation/technology-transfer assistance strategy.

By casting a wide net of investigation, the Committee uncovered what appears to be a number of problems permeating the processes of decision making at the Canada Foundation for Innovation and the three granting councils, as well as in the allocation of the Canada Research Chairs program. The Committee also has unanswered questions on the application of the National Research Council's cluster strategy and on the best federal-provincial funds transfer mechanism for post-secondary education. These problems and questions need to be investigated further and the Committee intends to do

exactly that in the fall. This report is, therefore, the first in a series of reports on Canada's innovation system.

The Committee is convinced that these recommendations, along with those that will emerge from the Committee's fall agenda, will provide a solid foundation to a federal innovation agenda and go a long way to eliminating the country's "innovation gap" with the United States. They will also better prepare Canadians and Canadian businesses for the opportunities and challenges presented by a knowledge-based economy. The Committee's objectives are real and obtainable; we begin with a well-educated labour force and a strong corporate culture. An innovative and productive Canada will be a competitive and prosperous Canada.

APPENDIX A
LIST OF WITNESSES

Associations and Individuals	Date	Meeting
Natural Sciences and Engineering Research Council of Canada	20/03/2001	4
Thomas Brzustowski, President		
Coalition for Canadian Astronomy	22/03/2001	6
Peter Janson, Chair and Chief Executive officer, AMEC Inc.		
Rene Racine, Emeritus Professor, “Département de physique, Université de Montréal”		
Andrew Russel Taylor, President, Canadian Astronomical Society		
Department of Industry	29/03/2001	9
Gilbert Normand, Secretary of State (Science, Research and Development)		
George Michaliszym, Director, Life Sciences Branch		
Marie Tobin, Director General, Innovation Policy Branch		
Canada Foundation for Innovation	03/04/2001	10
David W. Strangway, President and Chief Executive Officer		
Carmen Charette, Senior Vice-President		
Manon Harvey, Vice-President, Finance		
Alliance of Manufacturers & Exporters Canada	24/04/2001	13
Jayson Myers, Senior Vice-President and Chief Economist		
Statistics Canada		
John Baldwin, Director		

Associations and Individuals	Date	Meeting
Genome Canada	01/05/2001	16
Martin Godbout, Executive Director		
National Research Council of Canada		
Peter Hackett, Vice-President, Research and Technology Development		
John Root, Program Leader, Neutron Program for Materials Research		
Walter Davidson, Coordinator (National Facilities)		
Coalition for Biomedical and Health Research		17
Barry McLennan, Chair		
Charles Pitts, Executive Director		
Montreal Genome Centre, McGill University		
Thomas Hudson, Director, Assistant Director, Centre for Genome Research, Whitehead Institute / Massachusetts Institute of Technology		
National Research Council of Canada		
Peter Hackett, Vice-President, Research and Technology Development		
Canadian Space Agency	08/05/2001	20
Mac Evans, President		
Department of Finance		
Paul Berg-Dick, Director, Business Income Tax Division		
Department of Industry		
Jeffrey Parker, Executive Director, Technology Partnerships Canada		

Associations and Individuals	Date	Meeting
National Research Council of Canada	08/05/2001	20
Lucie Lapointe, General Secretary		
Margot Montgomery, Director General, Industrial Research Assistance Program (IRAP)		
Networks of Centres of Excellence		
Jean-Claude Gavrel, Director		
Office of the Auditor General of Canada		
Richard Flageole, Assistant Auditor General		
Peter Simeoni, Director		
Association of Universities and Colleges of Canada	15/05/2001	23
Robert Giroux, President		
Canada's Role in International Science and Technology		
René Simard, Chair		
Canadian Association of University Research Administrators		
Bruce Hutchinson, Past President		
Canadian Institutes of Health Research		
Allan Bernstein, President		
Commercialization of University Research		
Pierre Fortier, Director		
Natural Sciences and Engineering Research Council of Canada		
Thomas Brzustowski, President		

Associations and Individuals	Date	Meeting
Social Sciences and Humanities Research Council of Canada	15/05/2001	23
Marc Renaud, President		
René Durocher, Executive Director, Canada Research Chairs Program		
Canadian Association of University Teachers	31/05/2001	29
Paul Jones, Research and Education Officer		
Canadian Medical Discoveries Fund Inc.		
Calvin Stiller, Chair and Chief Executive Officer		
Conference Board of Canada		
Brian Guthrie, Director, Innovation and Knowledge Management		
Department of Industry		
Gwillym Allen, Assistant Deputy Commissioner of Competition, Economic Policy and Enforcement		
National Research Council of Canada		
Arthur Carty, President		
University of Toronto		
Nancy Gallini, Professor of Economics, Department of Economics		
Vancouver City Savings Credit Union		
David Mowat, Chief Executive Officer		

REQUEST FOR GOVERNMENT RESPONSE

Pursuant to Standing Order 109, the Committee requests that the government table a comprehensive response to this Report within one hundred and fifty (150) days.

A copy of the relevant Minutes of Proceedings of the Standing Committee on Industry, Science and Technology (*Meetings Nos. 4, 6, 9, 10, 13, 16, 17, 20, 23, 29, 31, 32, 33 and 34 which includes this Report*) is tabled.

Respectfully submitted,

Susan Whelan, M.P.
Essex

Chair

Canadian Alliance Dissenting Opinion
The Canadian Innovation Agenda
June 8, 2001

The third report of the Standing Committee on Industry, Science & Technology on innovation is part of an on-going study to deal with innovation, productivity, competitiveness and science & technology (S&T) in Canada. While the Canadian Alliance members of the standing committee feel that the main report does address some of the prominent issues concerning S&T policy in Canada, we feel compelled to offer a dissenting opinion in order to identify significant weaknesses in this report.

The most troubling matter is the government's long-standing refusal to acknowledge the failure of its own policies to encourage innovation and productivity. Liberal members who comprise the majority of the Committee do not recognize the role that successive Liberal governments have played in hindering Canadian economic progress and development. This state of denial is negatively impacting on Canada's standard of living, which is currently 30% lower than our American neighbours. (National Post: June 6, 2001)

The Canadian Alliance believes that by preserving a high tax regime, by not formulating a comprehensive and transparent policy on science and technology, and by maintaining its reliance on old-fashioned and unproven public expenditure programs to "fix the problem," the Government will continue to disappoint Canadians on this issue. Until the Government acknowledges its past failures and transforms its perspective, Canada will fall short of its S&T goals.

Taxation and the Effect of Public Policy

Canada's economic performance, when measured against the performance of our major trading partners, continues to be of great concern. Our productivity has fallen in comparison to other OECD countries and in particular at an alarming rate compared to that of the United States. Canada has fallen from 6th place in 1997 to 9th place in 2001 in the world competitiveness ranking.

The preface of the Committee's report asserts that: "Canadian businesses have historically been laggards in conducting R&D."(p. 3) The Alliance maintains that the fault lies with public policies over the past 30 years that have failed to cultivate a culture of innovation and competitiveness. We further believe that Canadian businesses, given a healthy business environment, would have confidence in the rewards of conducting R&D and would be more willing to take risks on innovation.

The Alliance is concerned that having the highest personal income tax burden in the G-7 and the highest corporate income tax rate in the OECD is having a negative effect on research and capital investment. Clearly tax reductions would directly address this issue, yet, the committee did not consider recommending such a policy. The timid planned tax cuts with their long phase-in periods outlined in the last Economic Update do little to encourage businesses and investors to take risks on innovation. Moreover, Canada's major competitors and trading partners are poised to embark on another round of tax cuts, leaving Canada even further behind.

The Business Council on National Issues and the Canadian Manufacturers and Exporters both agree that Canada cannot improve productivity without cutting taxes. Roger Martin, Dean of the Rotman School of Management at the University of Toronto, acknowledged that the Canadian private sector has under performed, but argued that the federal government has also not done enough:

> "The Canadian government has done nothing innovative in the past 25 years on tax policy. All they have done is replicate what has been done elsewhere. And in most cases, replicate it not as effectively," National Post (June 6, 2001):

Jason Myers told the Committee that with the current tax treatment of technology, discouraged innovation:

> "... we've seen the erosion of the ability of manufacturers to be able to write off equipment, to use tax credits to support their investment in new technology. But I think, more generally, since investment in capital simply follows profit performance, there are a lot of other factors that really affect the bottom line of a lot of companies, particularly smaller companies, that we also have to look at here. It's beyond that. Tax instruments are an important component of the problem, but certainly not the only one" (IST meeting #13)

He further noted: "One law of economics is if you want companies to do something, businesses to do something, then don't make it more expensive for them to do that." (IST meeting #13)

Recommendation One:

The Canadian Alliance recommends across the board tax cuts for businesses and individuals. The $1.3 billion capital tax on innovation should also be eliminated.

Recommendation Two:

The Canadian Alliance believes that the Standing Committee on Industry should immediately strike a joint committee with the Standing Committee on Finance and begin hearings on tax policy and the effect of taxes on capital stock, machinery and equipment, new technologies, and the connectivity strategy is having on productivity in Canada.

A Comprehensive Science & Technology Policy

The Canadian Alliance is concerned that the poor overall performance of public policy in S&T is somewhat related to parliamentarians limited knowledge of basic issues in science. Therefore, the Alliance believes the Parliamentary Office of the Chief Scientist should be created and instructed to report directly to Parliament to aid in the formulation of a comprehensive policy on science and technology.

Members of Parliament and Senators come from very different and diverse backgrounds and are often asked to make decisions on scientific issues they know very little about. The Chief Scientist would serve to advise parliamentarians with balanced and objective analysis of science and technology based issues of relevance to Parliament. The office would carry out studies in broad S&T based policy areas such as agriculture, defence, transport, environment and health as well as advise on issues of pure science and research. These reports should be made public.

Recommendation Three:

The Prime Minister, following consultations with the Opposition Parties, appoint a Chief Scientist to serve and advise parliamentarians on science and technology issues of relevance to Parliament.

Transparent Criteria for Science Funding

The Canadian Alliance has always believed in the importance of investing public money in S&T. The granting councils have had a good track record in S&T investment and we applaud their work. However, science and technology investments must be transparent and must be made in combination with a broader S&T policy framework, in addition to tax cuts, in order to create an overall environment more encouraging to innovation.

Alliance members are concerned that the current Government chooses to spend public money without a comprehensive, long-term S&T policy or regard for the outcome of spending initiatives. For example, the branding strategy currently being employed by Industry Canada has not been made public, and therefore we have no way of measuring the success or failure of the program. Moreover, the spectre of Government picking scientific winners and losers is troublesome, particularly in light of its poor track record and the leeching of partisan politics into expenditure programs in the past.

There are several “big science” projects that are currently being funded by or seeking funding from the federal government. These are projects that require large initial capital investments and long term plans in order to sustain competitiveness and funding and also employ many individuals. These projects include the light source synchrotron,

the long-range plan for astronomy, the Sudbury Neutrino facility, the Canadian Neutron facility, Genome Canada, Iter, etc.

The Alliance is unclear as to what, if any, decision-making process is employed by the Government to support one big science project over another as there are no apparent criteria for decision making in this field.

Industry Minister Brian Tobin initially told the Committee that big science decisions were made away from the Cabinet table based on advice from agencies such as NRC or NSERC:

> "All of the decisions on all of these programs are made at arm's length from me, from members of cabinet, from members of Parliament, from government generally. I think it takes a certain reserve and a certain determination, when you have a block of funds, as we're seeing this fiscal year — and we could use a big chunk of it to pay down the debt but part of to make strategic investments — to resist the temptation to go out and do the shopping list or wish list of projects that members, including me, might want to propose. Instead, we could say to an expert panel — in the case of Genome Canada, a panel from outside the country — of international experts, "Give us your best advice, based on the applications before us, as to where these strategic investments across Canada should go". (IST-3)

However, the Minister also said on the same issue:

> "These are the questions that would be determined by cabinet, specifically because they're large stand-alone projects." (IST-3)

The Alliance believes that making decisions on big science projects on an ad hoc, and potentially partisan basis is a poor policy practice. If there were a clear set of criteria, it would be much easier for scientists and parliamentarians to carry out their work. The Auditor General has examined this issue (December 2000) and discovered that the government does not have a structure to manage the approval, implementation and reporting of big science projects involving several departments and agencies. Clearly as we move into the next generation of science and health with the mapping of the genome, and as we move towards attracting more science and technology investment to Canada, the pressures to fund big science projects will continue.

Recommendation Four:

The Canadian Alliance agrees with the Auditor General that a framework for handling big science proposals is needed. This framework should include, but not be limited to, a full and public cost/benefit analysis conducted by a non-government agency and a peer review panel, situating the projects in reference to Canada's overall science and technology priorities, community impact assessments, briefs on the scientific nature of the project by the Parliamentary Office of the Chief Scientist, establishment of clear lines of accountability, and annual public reports.

Conclusion

Canada has the potential to be a world leader in innovation and entrepreneurship, and in science and technology. However, this will require the Government to engage in a fundamental public policy shift. In order to address our real public policy concerns, the Government should lower personal and corporate taxes, ensure that research and development funding occurs within an overarching long-term financial plan and establish clear criteria for large-scale science projects.

We must ensure that Canadian productivity does not slip any further behind the United States and other countries. Very specific actions must be taken by the government to ensure innovation and S&T are a significant part of the Canadian economy. Canadians have huge potential in this area, and given the right environment, will take up the challenge and succeed.

The Canadian Alliance hopes that the Government can muster the courage to tackle Canada's problems of low productivity and innovation. However, this cannot be done if the Government continues to deny to its own mistakes in this area. It's time for the Government to be truly innovative in creating an effective science and technology policy instead of relying on old-fashioned expenditure programs. Lower taxes, a Chief Scientist and transparency in government investment in S&T will go a long way to re-build the confidence of Canadian businesses and investors and to re-ignite the pioneering spirit that built this country.

Charlie Penson, M.P.
James Rajotte, M.P.

Supplementary Report: Progressive Conservative Party of Canada

> *"How can you have a paper on innovation without anything on taxes? You can't. It's a contradiction in terms." (Tom D'Aquino, President of the Business Council on National Issues.)*

The Progressive Conservative Party supports the general direction of the report from the House of Commons Standing Committee on Industry, Science and Technology entitled *A Canadian Innovation Agenda For The Twenty-First Century*.

For example, we support reform to the Canada Foundation for Innovation (CFI) to eliminate the systemic anti-small university bias.

It is clear that for Canada to compete in today's increasingly global, knowledge-based economy that we cannot standby while other countries leapfrog over us with more competitive tax regimes, more rational regulations and their resulting by improved productivity levels. To compete and win in a global economy, Canada's knowledge based industries need more innovative tax and regulatory reform.

However, the Liberal government's track record of the last eight years has included declining investment and productivity, a lower standard of living, record levels of taxation, and punishing regulations and red tape. There is no better barometer of this government's poor performance on competitiveness than the anaemic Canadian dollar, which has lost 12 cents or 16% of its value since 1993.

The Liberal response to Canada's declining standard of living and high taxes is to ask Industry Minister Brian Tobin and Human Resources Minister Jane Stewart to develop a white paper on productivity. It is unfortunate that this paper will reportedly propose significant government intervention, at significant taxpayer cost, but will not propose any reforms to Canada's tax and regulatory burden that could improve productivity.

High corporate and personal taxes reduce the incentive to work, save and invest. This hampers economic growth and reduces our productivity and standard of living. It is not just the level of taxation that matters, but also the structure of the tax system.

Canada needs a new agenda, a plan designed to allow Canadians to fully benefit from the opportunities of the new millennium. This government needs to ensure that the economic fundamentals are in place to allow Canadians to compete and thrive in the global economy.

The Progressive Conservative Party of Canada adds the following recommendations to the report:

1. Reform Corporate Taxes:

> *"I think if there is an argument for tax cuts leading to growth and investment, it would be more on the corporate side than on the personal tax side. I think it certainly comes out of the literature that there is a stronger impact." (Andrew Jackson, Chief Economist, Canadian Labour Congress)*

The government should fully implement the corporate tax reform recommendations of the Mintz Report. Tax reduction combined with tax reform can ensure that all sectors benefit from corporate tax reform. Corporate tax reform should seek to reduce the distortionary nature of our tax policy, reduce profit insensitive capital taxes, and in general reduce our corporate tax burden, which is currently the 2nd highest in the OECD.

To this end, the Progressive Conservative Party of Canada believes that the corporate tax rates should be lowered to the OECD average, which is to a combined federal and provincial rate of approximately 35 per cent immediately. Given current provincial corporate tax rates, this would suggest a federal corporate tax rate of about 20.5 per cent. Lower corporate taxes means more income for business that can be used to expand and attract and retain Canadian employees.

2. Personal Tax Relief and Reform

> *"The Canadian government has done nothing innovative…all they have done is replicate what has been done elsewhere. And in most cases, replicate it not as effectively. There needs to be a distinctive tax strategy to leapfrog the United States." (Roger Martin, Dean of the Rotman School of Management)*

Eliminating the personal capital gains tax would attract new investment and new talent to Canada's new economy. It would help give a leg-up to young Canadian companies fighting against intense competition.

Canada is losing too many engineers, scientists, doctors, nurses, managers and other professionals to the United States, with serious implications for our long-term economic health. A key challenge of government policy is to end the brain drain as quickly as possible- one this government continually refuses to address.

The personal capital gains tax damages the health of the economy in a profound way. Today there is no form of taxation that is more harmful in terms of its impact on the new economy than the capital gains tax.

Furthermore, it is essential that this current government address Canada's high marginal personal tax rates. Once all of the promised tax relief is in place by the federal and provincial governments, the average combined federal-provincial top marginal personal income tax rate in Canada for 2001 is 45.6 per cent. Most U.S. states have a top marginal tax rate in the 41 to 45 per cent range. Under President Bush's tax-relief plan, the top U.S. marginal personal income tax rate will be reduced to below 40 per cent in most states by 2003. In Canada, the top tax rate will kick in between $60,000

and $100,000 depending upon the province, whereas the U.S. top rate under Bush's plan will kick in at U.S.$136,751, or $214,000 in Canadian dollars. The marginal tax rates at lower income levels can be even higher in Canada due to the "taxback" feature of several federal and provincial social benefit programs.

3. Reducing the Regulatory Burden:

While the valid purpose of regulation is to protect consumers, the burden of excessive regulation constrains productivity growth, reduces competitiveness and causes higher prices. As we move closer towards a global economy, Canadian firms will face increasing competition. This government can no longer stifle Canadian enterprises- the engines of economic growth- with costly regulations.

The Progressive Conservative Party believes that every new regulation should be examined in a regulatory budget in Parliament. The government should implement a "Regulatory Budget," which would detail estimates of the total cost of regulation, including the government enforcement costs and the cost of compliance to individual citizens and businesses. The "Regulatory Budget" would also include a risk/benefit assessment of the regulation to enable cost-benefit analysis by parliamentarians.

4. Securities Regulatory Reform: Creating a Better Environment for Innovators:

The variety of provincial securities regulations continues to complicate efforts of entrepreneurs wanting to raise capital. A uniform set of securities regulations would improve the ability for innovators to raise capital in Canada. We feel it is important that the federal government work with provincial governments to develop a uniform approach to securities regulations.

5. Regional development:

The Canadian and global economy has undergone more changes in the past decade than in the previous hundred years. Regional development agencies, in their current form, are "old economy" vehicles that need visionary reform to harness the opportunities of the new economy.

Economic development agencies should continue to play a role in funding activities, which improve equality of opportunity for disadvantaged regions. In doing so, however, it is important that their activities do not crowd-out private sector investment. In some cases, for example, regional development agencies have encouraged entrepreneurs to opt for government financing when private sector capital financing would have been more beneficial in the long run. While private venture capital investment occurs with a cost of the loss of equity, it brings with it significant and important benefits. These include access to a high powered and connected board of directors, expertise in capital markets and investment banking and the global high technology community. Regional development agencies should be reformed to act as a catalyst to attract private sector

venture capital investment in the regions. Access to venture sector capital is more difficult in the rural areas of Canada and we need to tear down impediments to placing this capital in regionally disadvantaged areas. Regional development agencies could work through syndication to build teams of technologically savvy venture capital firms to invest in Canada. Regional development agencies should make it easier for private venture capital firms to invest in Canadian companies by reducing the risk. We feel government should establish a task force compromised of representatives of different industry sectors (high tech, tourism, value-added resources etc.) and the venture capital community, boards of trade, chambers of commerce and other interested parties to develop more effective regional development agencies.

Respectfully submitted by:

Scott Brison
M.P Kings-Hants
PC Party Industry Critic

MINUTES OF PROCEEDINGS

Thursday, June 7, 2001
(*Meeting No. 34*)

The Standing Committee on Industry, Science and Technology met *in camera* at 9:13 a.m. this day, in Room 112-N, Centre Block, the Chair, Susan Whelan, presiding.

Members of the Committee present: Reg Alcock, Mauril Bélanger, Pierre Brien, Scott Brison, John Cannis, Marlene Jennings, Walt Lastewka, Charlie Penson, James Rajotte, Paddy Torsney, Susan Whelan.

In attendance: *From the Library of Parliament*: Dan Shaw and Daniel Brassard, research officers.

Pursuant to Standing Order 108(2), consideration of the Science and Technology Policies.

The Committee proceeded to consider its draft report on Science and Technology.

Moved, — That the Draft Report (as amended) be concurred in.

Ordered, — That the Chair present the report (as amended) to the House at the earliest possible opportunity.

Moved, — That pursuant to Standing Order 109, the Committee request that the government table a comprehensive response to this report within one hundred and fifty (150) days.

Moved, — That the Chair be authorized to make such typographical and editorial changes as may be necessary without changing the substance of the draft report to the House.

Moved, — That 1000 English copies and 550 French copies of the report be printed with a special cover.

Moved, — That the Committee authorize the printing of dissenting opinions as an appendix to this report, immediately following the signature of the Chair.

Moved, — That any dissenting opinions be limited to not more than 5 pages.

Moved, — That any dissenting opinions be received by the Clerk in both official languages no later than Friday, June 8, 2001.

At 10:27 a.m., the Committee adjourned to the call of the Chair.

Normand Radford
Clerk of the Committee